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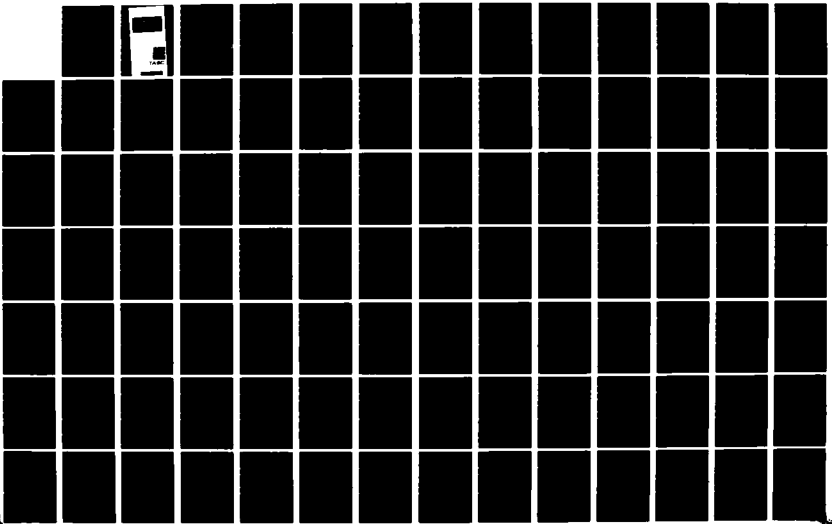

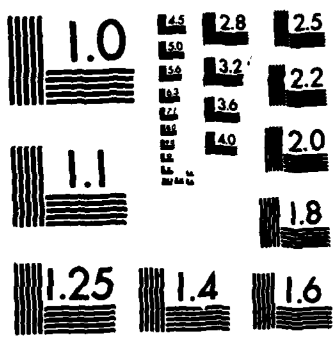
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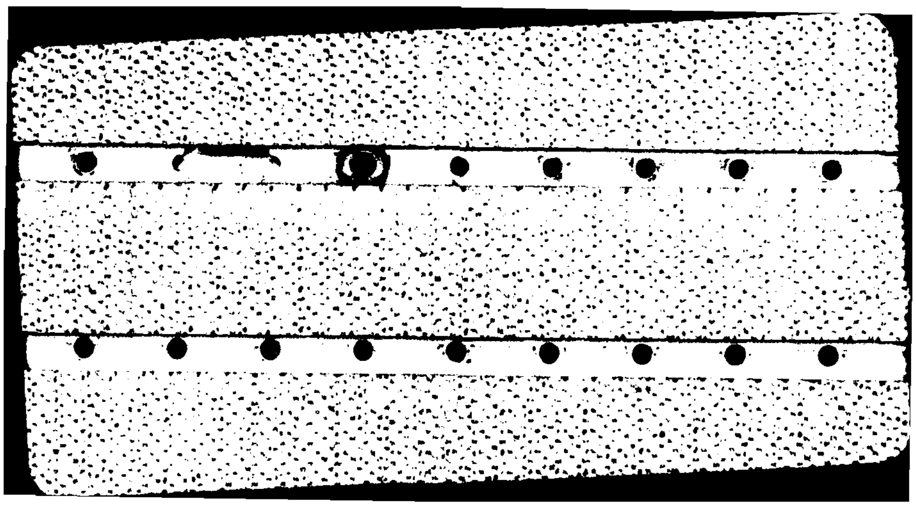

THE ANALYTIC SCIENCES CORPORATION

TR-1375

FEASIBILITY AND DEVELOPMENT STUDY FOR A SYSTEM ACQUISITION STRATEGY MODEL

FINAL REPORT

12 January 1981

The views, opinions, and findings contained in this report are those of the author(s) and should not be construed as an official Department of Defense position, policy, or decision, unless so designated by other official documentation.

Prepared Under:

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for

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The feasibility of developing an analytic model for use in selecting an acquisition strategy for research, development, and production of major weapons systems is studied in detail. The concept of weapon system acquisition strategy is broken into its constituent parts and thoroughly examined. A feasible modeling approach is described. It incorporate differing strategy alternatives, the impact of influencing factors, and the use of historical data by the development of a multiattribute utility model which can be tailored to reflect the needs and constraints of a particular program.

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ABSTRACT

The feasibility of developing an analytic model for use in selecting an acquisition strategy for research, development, and production of major weapon systems is studied in detail. The concept of weapon system acquisition strategy is broken into its constituent parts and thoroughly examined. A feasible modeling approach is described. It incorporates differing strategy alternatives, the impact of influencing factors, and the use of historical data by the development of a multiattribute utility model which can be tailored to reflect the needs and constraints of a particular program. A three-phase approach for full model development and implementation is recommended.

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EXECUTIVE SUMMARY

The Analytic Sciences Corporation (TASC), under contract to the Defense Systems Management College (DSMC), has performed research and analysis in order to assess the feasibility of developing an analytic model for use in selecting an acquisition strategy for research, development, and production of major weapon systems. In the conduct of this contract, TASC reviewed literature on the subject in depth -- previous research into the weapon system acquisition process, government policy and guidance relevant to weapon system acquisitions, and the use of decision analysis (a modeling process in which a decision maker contemplates a choice of action in an uncertain environment). Additionally, extensive interviews of knowledgeable and experienced individuals were conducted. Those interviewed included members of the Defense Science Board, program managers and members of their staffs, contracting officers, and acquisition policy planners. As a result of these efforts, TASC has determined that an analytic model for use in selecting a strategy for weapon system acquisitions is feasible, and a preliminary description of such a model has been developed.

The elements of acquisition strategy have been described as twenty-three strategy alternatives over four acquisition phases (Figure ES-1). These alternatives encompass feasible options for the development of a new weapon system and for a modification program to an existing weapon system, and in fact, they represent significant considerations in evaluating whether the development of a new system or a modification to an existing system is most appropriate for a perceived need. At each decision point in the acquisition process, the acquisition strategy

PHASE 0: CONCEPT EXPLORATION

- Directed Concept
- By Non-Industrial Firms
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- Waive D&V
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- Single Source With Options
- Single Source, Multi-Year Contract
- Leader-Follower
- Licensing
- Second Sourcing

Figure ES- 1 Acquisition Strategy Alternatives

is defined as the option selected from feasible alternatives as the course of action for the current phase and a planned course of action for subsequent phases. It considers the uniqueness of the specific case, relevant historical data, and relevant budget and policy constraints. Acquisition strategy is thus characterized by a dynamic decision-making process which is updated and refined to incorporate changing conditions and the increasing state of knowledge.

An extensive list of significant factors and considerations influencing the strategy alternatives has been compiled. Each factor was considered significant by at least two sources. Each factor is discussed, and each has been categorized as to the type of influence it exerts, by acquisition phase.

Preliminary forms of quantitative relationships have been developed which combine the impact of relevant influencing factors and their associated uncertainty to indicate the expected result of pursuing an acquisition strategy alternative. The resulting attributes provide decision-oriented answers to questions involving time, cost, affordability, technical risk, etc., together with the uncertainties associated with each.

Four major weapon system acquisition programs were examined in detail to ascertain the availability of data in sufficient quantity and quality to support the development of an historical data base. From this, TASC concluded that sufficient data exist; however, an intense data collection effort will be required to establish an adequate data base.

A feasible modeling approach is described which incorporates the differing strategy alternatives, the impact of the influencing factors, and the use of historical data by the development of a multiattribute utility model. The model can

then be tailored to reflect the needs and constraints of each particular program. The multiattribute utility model, properly structured, would provide a means to systematically identify and structure objectives, to make vexing value trade-offs, and to balance various risks. A conceptual description of the proposed model is depicted in Figure ES-2.

Finally, a three-phase approach for full model development is presented. Phase I involves the development of a preliminary model and data base. Following this the preliminary model is evaluated by using it to assist program managers with acquisition strategy decisions, performed concurrently with additional data base development. The final phase calls for updating the model to incorporate lessons-learned during the evaluation phase, followed by full model implementation and documentation.

Properly implemented, the resulting model and data base would provide a valuable tool for a program manager to sort out conflicting values, objectives, and goals, and to aid him in selecting a wise acquisition strategy. This could be especially valuable in the beginning of a program's life, as well as at each critical point in a program's evolution.

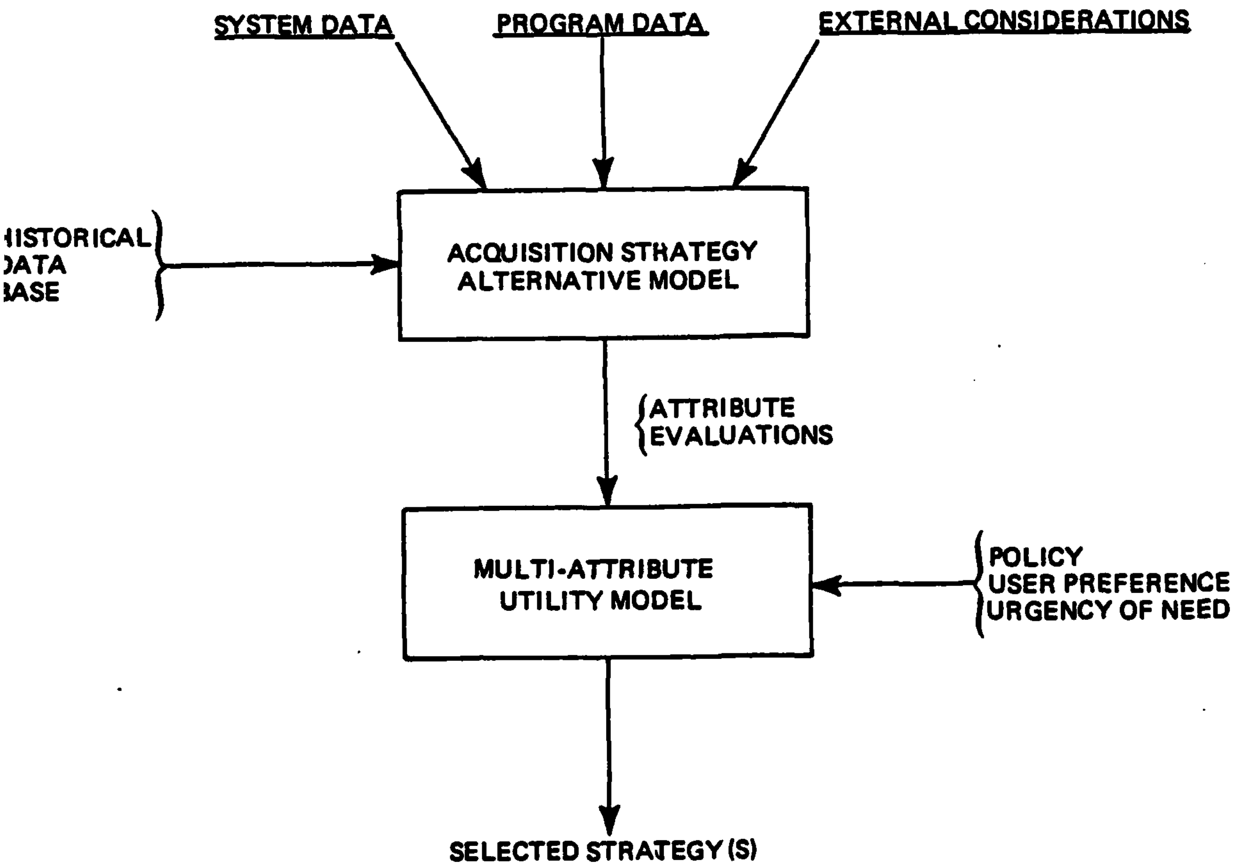

Figure ES-2 Conceptual Description of Model

1. INTRODUCTION

1.1 THE ACQUISITION ENVIRONMENT

Throughout the 1950s and early 1960s, weapon system acquisitions were highly motivated by the belief that the U.S. must overcome a Soviet missile threat. The acquisition process was controlled by the component services, and acquisition strategy was oriented towards performance and schedule. Cost growth, slipped schedules, and changes in performance requirements were common; emerging technology and system integration concepts were new; and expectations were frequently unsatisfied.*

The widespread belief that improvements could and should be made in the weapon system acquisition process prompted a reorientation of policy in the mid 1960s. In July 1965 Secretary of Defense McNamara issued Department of Defense Directive (DoDD) 3200.9 on the subject of Concept Formulation and Contract Definition. This detailed 16-page directive defined the activities that must be accomplished prior to full-scale engineering development, it centralized the weapon system acquisition authority in the Office of the Secretary of Defense (OSD), and it established a format for weapon system development strategy.

The highly structured format established by DoDD 3200.9 was criticized by the Blue Ribbon Defense Panel Staff Report on Major System Acquisitions (1969-1970). In May of 1970, Deputy

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* Peck, M.J. and Schere, F.M., "The Weapons Acquisition Process: An Economic Analysis," Harvard University, Boston, 1962.

Secretary of Defense Packard issued policy guidance that formed the framework of the Defense System Acquisition Review Council (DSARC) process. This was subsequently formalized in DoDD 5000.1, 13 July 1971 (which replaced DoDD 3200.9). The thrust of this new directive was to decentralize decision-making from OSD to the component Services,* to establish the DSARC milestones, and to define the elements that support each Secretary of Defense (SECDEF) decision. This directive recognized for the first time the role of the program manager in establishing and implementing acquisition policy. The 1971 version of DoDD 5000.1 constituted the beginning of a process of introducing flexibility into the highly structured weapon system acquisition process.

The acquisition style of the 1970s could be characterized by the expanding use of competitive prototypes and the implementation (to various degrees) of design-to-cost, design-to-life-cycle-cost, and fly-before-buy philosophies. Throughout the 1970s, many studies were conducted that provided an orientation for successive Department of Defense policy guidance documents. Reports from the Commission on Government procurement (1972), the Navy and Marine Corps Acquisition Review Committee (1975), the Army Material Acquisition Review Committee (1974), together with The Air Force System Command, Project ACE studies (1974-1975) and the Acquisition Advisory Group Report (1975) all established an environment that encouraged the use of a tailored acquisition strategy. In 1976 the Office of Management and Budget (OMB) issued Circular A-109 which provided guidance to all federal agencies concerning major system acquisitions. This circular directed a flexible and tailored approach for each system development.

*While the Services had the prerogative to propose and later implement the acquisition plan, OSD retained control over all new program starts.

A review of current government policy documents, ranging from OMB Circulars through Service Material and System Command directives, indicates that the developing agency or program manager is to tailor the acquisition strategy or plan to the unique circumstances of the system to be developed. Policy guidance is very broad, stressing the desirability of meeting affordability objectives, maintaining competition, using federal funds for socio-economic goals, minimizing the development cycle time, etc. Although certain information is to be acquired and value judgements are to be made prior to each DSARC milestone, specific methods of development are not mandated. The current versions of DoDD 5000.1 and DoDI 5000.2 (and their influenced directives) do not require a specific format for weapon system development. The Defense Acquisition Regulations (DAR) describe conditions and circumstances for different contract types, for the use of contract options, for multi-year contracts, etc., and they specifically prohibit the use of a Total Package Concept as it was known during the 1960s and early 1970s. All three Services develop and procure weapon systems using essentially the same acquisition techniques.

1.2 STUDY OBJECTIVES

The acquisition environment described in Section 1.1 vividly protrays the deep concern there has been for a number of years over the effectiveness of the management of major weapon system acquisitions. A methodology for systematically assessing the numerous issues involved in the weapon system acquisition process would provide a practical tool for a program manager to select the most appropriate management process for his program. In this regard, the <u>objective</u> of this study was <u>to assess the feasibility of developing an analytical</u>

model for use in selecting an acquisition strategy for research, development, and production of major weapon systems. A modeling approach was deemed desirable because of:

- The complexity of the structure of the entire acquisition process as fashioned and constrained by current policy documents
- The large number of interrelated and competing objectives associated with the acquisition of a major weapon system
- The large number of strategy options which must be considered at one time
- The high level of uncertainty associated with the possible outcomes of any decision.

Specific tasks delineated in the statement of work in support of the study objective are as follows:

- TASK A -- Provide a definition or description for each element of acquisition strategy (e.g. full competition, partial competition, competition by phases, etc.) as constrained/required by current major system acquisition policy documents.
- TASK B -- List significant factors, characteristics, or considerations influencing the acquisition strategies, and identify the general effects of each on the strategy, including the development of a descriptive model and taxonomy of significant factors.
- TASK C -- Define measurable relations between the influencing factors of Task B and the acquisition strategies of Task A.
- TASK D -- Examine past and/or present major system acquisition projects from each military service and a joint program and determine the availability of statistical data of the type required for the measurable relations defined in Task C.

- TASK E -- Advise the Defense Systems Management College (DSMC) regarding the feasibility of developing a practical model of the relations defined in Task C, and availability of statistical data in Task D. If such a model is deemed feasible, propose an approach which includes a description of the model, its methodology and possible operating characteristics, as well as estimated schedules and funding requirements.

1.3 RESEARCH METHODOLOGY

In order to assess the feasibility of developing an analytical model for use in any context, it is imperative to understand the environment and processes involved, and to learn how the relevant issues are handled today and have been handled in the past. Accordingly, the initial effort concentrated on three activities performed concurrently:

- A survey of the literature, particularly major studies concerning weapon system acquisitions, to identify previous efforts and to permit the assimilation of their analysis and findings into the current research effort
- A review of current government policy directives issued by the Office of Management and Budget, the Department of Defense, and the Services, to clarify the framework in which acquisition strategy is currently implemented, and to identify those elements that are directive in nature and those that are discretionary
- A review of documentation available in the Washington area that provided insight into the evolution of individual programs.

Once these activities were well under way and a preliminary framework encompassing the weapon system acquisition process had been established, interviews with experienced and knowledgeable individuals ensued. Individual interviews were

conducted with current and previous program managers, deputy program managers, key members of the program management staffs, contracting officers and their support groups, members of acquisition policy organizations in the Services and in OSD, and with members of the Defense Science Board. (A complete list of personnel interviewed is contained in Appendix D.) During the course of the interviews, as a program history was being described, the reasons, circumstances, and factors that influenced the development and procurement plan, and the rationale for selecting a particular strategy were elicited. Concurrently with the interview process, program files and available documentation were reviewed to ascertain what data have been recorded, in what form, and where.

The remainder of the research methodology involves many subjective aspects which are much more difficult to describe. The activities associated with TASKS A,B, and D - determining what the alternatives are for acquisition strategy, identifying critical factors, and obtaining a notion of what the principal decisions are and what sort of tradeoffs are likely to ensue in a comparison of the alternatives -- all contribute to a conceptual framework of how acquisition strategy might be modeled. Once the conceptual framework is formulated, the remaining tasks consist of quantifying the identified relationships in mathematical form and in assembling the many pieces in a manner amenable to some form of mathematical model. It is virtually impossible to arrive at a checklist for infallibly selecting and developing a model, and the process is frequently as much an art as it is a science. This process constituted the remainder of the research effort.

1.4 REPORT CONTENT

This chapter has described the acquisition environment, the objectives of this research effort, and the approach taken by TASC to accomplish those objectives.

Chapter 2 contains the results of TASK A. The elements of acquisition strategy are described as twenty-three strategy alternatives over four acquisition phases. At each decision point, the acquisition strategy is defined as the option selected from feasible alternatives as the course of action for the current phase and a planned course of action for all subsequent phases. It considers the uniqueness of the specific case, relevant historical data, and relevant budget and policy constraints. Acquisition strategy is thus characterized by a dynamic decision-making process which is updated and refined to incorporate changing conditions and the increasing state of knowledge.

In Chapter 3, the significant factors and considerations which influence the acquisition strategy alternatives are described. The factors are defined, classified into nine groupings, and categorized as to the type of influence each exerts, by phase of the acquisition process.

Preliminary estimates of quantitative relationships between the influencing factors and the expected result of choosing a particular acquisition strategy are presented in Chapter 4. These quantitative relationships, while subject to change, comprise a consistent set suitable for preliminary model development.

In Chapter 5, four major system acquisition projects are examined. A synopsis of each project is presented, and

the availability of data is discussed. In general, sufficient data exist but an intense data collection effort is required.

In Chapter 6, the feasibility of developing an analytical model for use in selecting an acquisition strategy is discussed and a preliminary model description is presented. A three-phased approach is outlined for the development of a model and data base for use in selecting an acquisition strategy.

Appendices A and B describe the results of prior work performed by TASC regarding the effects of competition during production. Appendix C indicates how these results could be incorporated into a generalized model for acquisition strategy. Appendix D contains a complete list of persons interviewed; Appendix E provides a bibliography of relevant publications.

2. ACQUISITION STRATEGY ALTERNATIVES

DODI 5000.2, 19 March 1980, defines acquisition strategy as follows (emphasis added by the authors):

> "Acquisition strategy is the conceptual basis of the overall plan that a program manager follows in program execution. It reflects the management concepts that shall be used in directing and controlling all elements of the acquisition in response to specific goals and objectives of the program and in ensuring that the system being acquired satisfies the approved mission need. Acquisition strategy encompasses the entire acquisition process. The strategy shall be developed in sufficient detail, at the time of issuing the solicitations, to permit competitive exploration of alternative system design concepts in the Concept Development phase. Additionally, sufficient planning must be accomplished for succeeding program phases, including production, for those considerations that may have a direct influence on competition and design efforts by contractors. The acquisition strategy shall evolve through an iterative process and become increasingly definitive in describing the interrelationship of the management, technical, business, resource, force structure, support, testing and other aspects of the program."

Information from the literature survey, review of government policy directives, and interviews with experienced and knowledgeable individuals, have led to the elements of acquisition strategy being described as 23 strategy alternatives over four acquisition phases (Figure 2-1). These alternatives encompass feasible options for the development of a new weapon system and for a modification program for an existing weapon system. In fact, they represent significant considerations in evaluating whether the development of a new system or a modification to an existing system is most appropriate for a perceived need. Consistent with this representation, the following incorporates these strategy alternatives into a

of acquisition strategy appropriate for this effort. At each decision point in the acquisition process, the acquisition strategy is the option selected from feasible alternatives as the course of action for the current phase and a planned course of action for subsequent phases. It considers the uniqueness of the specific case, relevant historical data, and relevant budget and policy constraints. Acquisition strategy is thus characterized by a dynamic decision-making process which is updated and refined to incorporate changing conditions and the increasing state of knowledge.

Throughout the remainder of this chapter, a convention is adopted where the set of strategy alternatives for each phase of the acquisition process is represented by the capital letter A with a superscript to denote the particular phase. The following notation results:

- A^0 denotes the set of strategy alternatives for Phase 0, Concept Exploration
- A^1 denotes the set of strategy alternatives for Phase 1, Demonstration and Validation
- A^2 denotes the set of strategy alternatives for Phase 2, Full-Scale Development
- A^3 denotes the set of strategy alternatives for Phase 3, Production and Deployment.

Individual strategy alternatives are then represented by the capital letter A with both a superscript and a subscript. The superscript denotes the phase of the acquisition process and the subscript denotes a particular strategy alternative within that phase. The correspondence between subscript number and strategy alternative is presented as the alternatives for each phase are discussed.

The remainder of this chapter is devoted to a detailed description of the strategy alternatives by acquisition phase.

PHASE 0: CONCEPT EXPLORATION

- Directed Concept
- By Non-Industrial Firms
- By Industrial Firms

PHASE 1: DEMONSTRATION AND VALIDATION (D&V)

- Waive D&V
- Contract Definition
    - By Non-Industrial Firm
    - Industrial Firm (Single Source)
    - Industrial Firms (Multiple Sources)
- Subsystem and/or Component Development
    - By Non-Industrial Firm
    - Industrial Firm (Single Source)
    - Industrial Firm (Multiple Sources)
- System Prototypes
    - By Non-Industrial Firm
    - By Industrial Firm (Single Source)
    - By Industrial Firms (Multiple Sources)

PHASE 2: Full-Scale Development (FSD)

- Incremental Development
    - Single Source
    - Multiple Sources
- Concurrent Development
    - Single Source
    - Multiple Sources

PHASE 3: PRODUCTION & DEPLOYMENT

- Single Source, No Options
- Single Source with Options
- Single Source, Multi-Year Contract
- Leader-Follower
- Licensing
- Second Sourcing

Figure 2-1 Acquisition Strategy Alternatives

2.1 CONCEPT EXPLORATION PHASE

The primary objective of concept exploration is to examine feasible solutions to the operational need as recognized by DOD in the Mission Element Need Statement (MENS), select those that exhibit potential, and then narrow the field to a manageable number for further development. As a first step in concept exploration, the need is described in operational terms rather than as technical requirements or system design parameters that might foreclose the consideration of alternatives. The proposed system or concept must, however, recognize and be consistent with various constraints and requirements imposed by DOD and the component Service. The more common of these issues are as follows:

- Urgency of need and schedule considerations
- Priority of need within the overall mission area, particularly with respect to other programs that will be competing for limited funds
- Amount of funds the developing Service has available, and an estimate of funds (order of magnitude) that will be budgeted in the outyears to finance the program. These early estimates not only indicate the level of Service support, but also the expected scale of the solution. Although it is premature to establish a firm design-to-cost goal, the magnitude of resources to be committed usually establishes the range of physical parameters of candidate solutions
- Safety, health, and environmental considerations
- Manpower, training and logistics factors
- Inter-service and NATO compatibility, if applicable

Interdependencies with other systems, interface and compatibility constraints, and requirements to incorporate GFE into system designs.

task of the program manager is to establish and man-dgeable yet unbiased organization that can elicit alternative solutions subject to program constraints. literature refers to this phase of the system acqui-ss as a conceptual competition, it may properly be concept rivalry since the proposals and subsequent es seldom are accompanied with convincing physical t one concept is technically or economically supe-her. This situation requires the government eval-to exercise considerable subjective judgments he selection of the best concepts for further devel-ther, since an acceptable solution may take many nge in United States or North Atlantic Treaty (NATO) doctrine, different employment of existing commercial systems, modification or improvements systems, or the development of a new system -- the oration staff or program managment office must pos- range and depth of knowledge.

three general strategies which exist for concept are depicted in Figure 2.1-1.

Directed Concept

n the deficiency is such that only one logical ap-plicable, the Secretary of the Service originating y recommend that a single concept be pursued.† With

---

ment Need Statement.

the concurrence of the Secretary of Defense, concept exploration is waived and the demonstration and validation phase may begin for the single directed concept.

$$A^o = \begin{bmatrix} A_o^o \\ A_1^o \\ A_2^o \end{bmatrix} \begin{array}{l} \text{Directed Concept} \\ \text{Non-industrial Solutions} \\ \text{Industrial Solutions} \end{array}$$

Figure 2.1-1 Phase 0 Strategy Alternatives

2.1.2 Concept Exploration By Non-Industrial Organizations (A_1^o)*

This alternative would establish a government organization to both create and evaluate concepts. This procedure is often used as an unofficial or ad hoc technology and tactics assessment to narrow the range of alternatives. It is also used to properly pose the mission requirement prior to formally opening the Concept Exploration Phase to competitive firms (A_2^o). This preliminary assessment provides the program manager with an indicator of the expertise required to evaluate concepts and ultimately manage the program.

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*The term non-industrial organizations is used for brevity; however, the broader intent is to include government engineering centers, laboratories, arsenals, federally funded research centers, educational institutions, not-for-profit corporations, and profit oriented firms that do not manufacture or produce hardware or computer software. The principal distinction is that this group usually lacks the insight into the discreet segment of the industrial economy that will ultimately dictate the production price of the end item and create or inhibit a competitive environment. Further, a technology transfer would have to be effected between the Concept Exploration organization and subsequent developers.

In many cases government organizations may provide a better insight into the users preference, existing weapon systems, and U.S./NATO tactics than could be provided by industry.

This acquisition alternative is the accepted procedure regarding naval ship acquisition programs. The Concept Exploration Phase is referred to in ship acquisition literature as the Feasibility/Conceptual Phase. This effort is an iterative dialogue between the user and material command. The ship's mission, operating requirements, major configuration constraints, overall maintenance concepts, supply support concepts, manning limitations, operating standards, and tentative cost goals are considered within the context of various general hull configurations, propulsion systems, weapons, and sensors. The result is a preliminary concept that delineates the alternatives that show promise of meeting the users Top Level Requirements* and cost constraints.

2.1.3 Concept Exploration by Industrial Organizations (A_2^o)

This alternative is specifically called out as the strategy of choice by OMB Circular A-109 and the derivative DOD Directives. The intent is to solicit from industry the widest possible range of innovative and creative system designs, logistic support concepts, and maintenance concepts. This competitive solicitation, defining the Service's mission need in operational terms and the system or program contraints, is to be presented to a broad base of qualified industrial firms. Creative solutions may also be provided by government organizations, educational institutions, small businesses and foreign firms. In

*Top Level Requirements (TLR) represent the user's needs and are more definitive than operational requirements (OR). OPNAVINST 9010.300 refers.

those cases where the system concept is based on government funded research and data rights are well defined, a transfer of technology to the eventual D&V or FSD contractor is rather straightforward. Concepts or technology based on private research by firms incapable of manufacturing the end item may create complex teaming or licensing arrangements or potential legal difficulties. The potential use of foreign made hardware may require a waiver to the "Buy American" restrictions in the DAR. None of these factors are severe enough to warrant eliminating a potential system concept from contention. However, the Program Management Office (PMO) staff must recognize the uniqueness of the situation and structure the acquisition plan accordingly.

In those cases in which a laboratory or not-for-profit organization proposes a system concept and will probably be directly involved in subsequent development, the proposing organization is precluded from participating in the concept evaluation process.*

2.2 DEMONSTRATION AND VALIDATION PHASE

The Demonstration and Validation Phase (D&V) of the acquisition cycle is concerned with those tasks that will reduce perceived technical and subsequent financial risk. The objective is to demonstrate that the technology required to implement a particular concept is primarily an engineering application rather than an experimental effort, and is appropriate for the intended use. Through these D&V efforts, the developing agency will attempt to select the concept(s) that best satisfies the mission need, affordability constraints, and schedule requirements. The quantification of technological

*DODI 5000.2

and financial risk during the D&V phase forms the basis for a full scale development (FSD) and production commitment.*

The program manager (PM), based on his experience and the advice of his technical staff, makes a subjective assessment of risks associated with the concepts under consideration and selects an appropriate alternative strategy for the D&V effort. This choice is tempered by the urgency of need, political considerations and the availability of funds. The program manager must first decide:

- Is there sufficient reason to waive the D&V effort and proceed directly into FSD, or perhaps combine these activities? If not,

- Which of the nine basic alternatives displayed in Figure 2.2-1 best satisfies the program's goals?

$$\begin{array}{ll} \text{Waive D\&V} & \begin{bmatrix} A_o^1 \end{bmatrix} \end{array}$$

$$\begin{array}{lccc}
 & \underline{\text{Government Activity Development}} & \underline{\text{Single Source Development}} & \underline{\text{Multiple Source Development}} \\
\begin{array}{l} \text{Contract Definition} \\ \\ \text{Subsystem and/or Component Test} \\ \\ \text{System Prototyping} \end{array} & \multicolumn{3}{c}{\begin{bmatrix} A_{11}^1 & A_{12}^1 & A_{13}^1 \\ \\ A_{21}^1 & A_{22}^1 & A_{23}^1 \\ \\ A_{31}^1 & A_{32}^1 & A_{33}^1 \end{bmatrix}}
\end{array}$$

Figure 2.2-1 Phase I Strategy Alternatives

*A FSD commitment is also a production and deployment commitment subject to the need persisting.

These alternatives can be expressed as a matrix of prime resources versus scope of work (see Figure 2.2-1). Within this matrix tasks to identify and reduce elements of technical and future financial risk become more definitive as one moves to the right and downward. Waiving D&V efforts (A_o^1) presents a situation with the most uncertainty, but at a minimum phase cost and delay; competitive or parallel system prototyping (A_{33}^1) requires the most time and money to complete, but is the most comprehensive endeavor.

2.2.1 Waive D&V Phase (A_o^1)

Provisions are made in DOD policy* to tailor the acquisition strategy as appropriate for a particular program.† When the perception of technical risk is minimal and/or the urgency of need dominates risk factors, the PM may elect to waive the D&V Phase and, with the approval of his Service Headquarters and the Defense Acquisition Executive (DAE), enter directly into FSD. This mode is consistent with many major weapon system modification or upgrade programs whose complexity and size require management techniques identical to those of a major system acquisition.‡

2.2.2 Contract Definition (CD) (A_{1-}^1)

Contract Definition (row one of Figure 2.2-1), once the directed technique for major weapon system acquisitions, is

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*DODD 5000.1 pp. 3 para. f., OMB Circular A-109, and DODI 5000.2, pp. 12, para. h.

†DODD 5000.1 pp. 1, para. C states that to minimize the time from need identification to introduction of a system into operational use is a DOD policy to be implemented in each major program where consistent with other constraints.

‡C-130 gunship mod program, etc.

no longer discussed in either the Defense Acquisition Regulations (DAR) or DOD policy documents. Nonetheless, the tasks associated with the classical CD may be applicable to the D&V effort of some programs. Historically, CD was a relatively short, intense planning, trade-off and evaluation effort accomplished under prevailing DOD policy of the late 1960s.* CD was limited to six months, with four months the norm.

The results of critical experiments and research, done either at the direction of DOD or through independent industrial/educational R&D, were incorporated into a unique plan for FSD and production. The CD, as the name implies, provided the cost, schedule, performance specification, management technique, and the related program parameters which formed the basis for FSD contract negotiation. In such a constrained time period of performance, CD seldom included hardware or software development tasks.

<u>Contract Definition by a Government Laboratory</u> (A^1_{11}) - (This includes federally funded research and development centers, educational institutions, and other not-for-profit organizations.) This alternative is appropriate only when the laboratory initially participated substantively in the advanced development activities that will form the technical base for FSD. Further, the laboratory must have both the technical and management skill to adequately define the FSD effort and to effect a smooth transition of technology to the industrial firm that will be responsible for full-scale development. Special cases of this alternative exist:

- The developing laboratory may assume a technical management role and guide the industrial firm in the next phase of development

*DODD 3200.9 of July 1965, now cancelled.

- A split D&V phase in which, a laboratory CD effort (A^1_{11}) is coupled with a limited in-house component development.

Contract Definition By A Single Industrial Firm (A^1_{12}) - In this unique alternative, three important decisions have already been made: a single concept has been selected during the concept exploration phase for further development, competition cannot be reasonably established, and a CD effort would satisfy the pre-FSD requirements. This alternative could well be applied to a major modification program in which only one company had the requisite technical knowledge to accomplish the task.

Contract Definition by Multiple Industrial Firms (A^1_{13}) - This alternative is consistent with DOD/OMB policy to maintain competition as long as economically feasible. It provides an element of program and design competition for FSD to firms with promising technical concepts. A well structured RFP for CD would delineate the government's requirements in terms of operational need, cost and schedule constraints, GFE and interface requirements, and logistic considerations. These parameters are necessary for industry to provide sufficient detail in their proposals to meet Milestone II decision requirements*. Further, these proposed performance and (often innovative) support concepts must be presented to the user community for

*DODI 5000.2 requires the following at Milestone II: an assessment of system effectiveness; updated acquisition strategy; plan for FSD; test and evaluation plan; design to cost goals; performance goals and thresholds; LCC estimates; adequate funds in the Service budget to accomplish FSD, T&E production, support and product improvement, and the imposition of design standardization concepts; a firm operational concept; manpower and training requirements; and R&M goals and thresholds.

concurrence before a Service commitment is made. This situation is always a negotiation process, not a decision process.

2.2.3 <u>Subsystem and Component Development</u> (A^1_{2-})

This is a range of activities (row two of Figure 2.2-1), short of full system prototyping, in which critical elements of a system are developed and major subsystems designed and tested. The vendor and subcontractor community is surveyed for future source of supply, expertise, and willingness to participate. Production plans and logistic support alternatives are examined, trade studies accomplished, and optimum solutions advocated.

Within the last decade, computer simulation has emerged as a powerful tool in system design, and it is uniquely applicable to this development alternative. The range of simulation varies from simple interface modeling through hybrid hardware/software development efforts to extensive wrap-around simulation programs. The latter both predicts system performance and plays a major role in establishing subsystem requirements during system integration.

<u>Government Laboratory Subsystem Development</u> (A^1_{21}) - This is applicable only when a government facility has extensive experience in the applicable technology base and has particular insight into the operating environment in which the subsystem will ultimately exist. Since government laboratories seldom have the facilities for total system development, are not equipped for production, and indeed are not established to compete with the private sector in manufacturing tasks, this alternative functions best in combination with other D&V strategies such as (A^1_{22}, A^1_{23}). In some cases this strategy has been adopted as a remedial or "get well" measure when industry

was unable to develop a satisfactory solution to a particular problem. This strategy element is also applicable in those cases in which the private sector does not have the capability to develop the subsystem or component in the time required by the program schedule. Manufacturing technology programs for high cost, high risk items are good candidates for this alternative.

<u>Subsystem and Component Development and Demonstration By a Single Contractor</u> (A^1_{22}) - In this mode one company (or team) develops and demonstrates significant elements of a single system concept. This concept was selected from or as a result of, the deliberations of Phase Zero. Often a technical concept put forward by a contractor is generally acceptable, but subject to revision by a government laboratory or the PMO to bring it into a form more acceptable to the ultimate user. The decision to pursue one concept with only one source is usually based on the physical and financial impracticality of demonstrating alternative concepts.*

As total quantities shrink and complexity increases, as is the case with major test range control systems, strategy (A^1_{22}) often merges with (A^2_{11}) or (A^2_{21}), single source full-scale development. This process is characterized by configuring a brass board system of military and commercial hardware and software and iteratively upgrading or substituting modules. The official demarcation between demonstration and FSD is often artificial. The end product of FSD may be the only system ever built if the DOD requirement is for only one.

<u>Multiple Source Subsystem Development and Demonstration</u> (A^1_{23}) - This is a preferred approach in many cases, particularly

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*Reference OMB-A-109, pp. 10.

when high volume production or high development risk is anticipated. It continues an active competition between rival system concepts and their industrial proponents. This strategy provides insight into the advantages and shortcomings of technical solutions through extensive study and analysis coupled with a degree of component hardware development. The determination of an appropriate degree of component or subsystem development is no mean task. OMB Circular A-109 (paragraph 11j) and OFPP Pamphlet No. 1, dated August 1976, state that subsystems are not to be "fully developed" until such subsystems are identified as integral parts of a weapon system that is approved for Full-Scale Development. This admonition also applies to component development. Although OMB Circular A-109 states, "This restriction is neither meant to inhibit the demonstration of new and innovative technology advancements, nor to inhibit the development and testing of components which will have a common applicability to several major systems," it does restrict the degree of subsystem development unique to one major system. The problem is to balance the degree of D&V development, the time required to produce mature subsystems, the desire to minimize total throughput time to an initial operational capability (IOC), and the cost associated with competition. Should state-of-the-art technology be required to support the desired performance of a new system, development of a critical subsystem could pace the entire system schedule. Also undesirable would be the failure of a potential weapons concept to survive the competitive demonstration and validation phase simply because its performance was dependent upon a subsystem whose development was severely constrained or incomplete.

Component and/or subsystem development demonstration is a technique that is applicable whenever perceived system integration risks are acceptable.

2.2.4 <u>System Prototype</u> (A^1_{3-})

This mode of demonstration (row three of Figure 2.2-1) calls for designing and building a prototype of the production end item. The objective is to physically demonstrate subsystem hardware and software compatability and degree of interdependence through the construction of a complete system. The prototype may take the form of existing military and commercial hardware linked with minimal developmental interfaces to demonstrate a new potential that will be fully developed in subsequent phases. At the other extreme, system prototyping could represent an advanced brass-board of a complete system that very closely approximates production performance.

<u>System Prototyping by a Government Activity</u> (A^1_{31}) - As a prerequisite for this alternative, the laboratory or engineering center must have significant prototyping experience and must have actively developed the technology that forms the basis for the desired change in weapon system performance. This alternative has been used successfully when:

- The total inventory requirements for the end item are very small and within the fabrication capabilities of the laboratory, and the technology requirements or security considerations preclude use of the private sector

- A laboratory developed subsystem is to be incorporated into an existing system. For example, a new or significantly modified guidance subsystem could be developed and integrated into an existing missile by a laboratory

- The results of this prototyping effort could be translated into a highly definitive statement of work suitable for pre-production development by industry. In some cases a data package of sufficient quality could be created that would allow competitive production of the next weapon system buy. The data package could also serve as the base for competitive field modification of existing systems

- The exploration and advanced development activity of a laboratory produce a solution to a specific military problem. The characteristics and risks of the weapons concept are such that a laboratory built system prototype would be a cost-effective alternative to either multiple or single source FSD. The issue is to determine if maintaining the laboratory's momentum through prototyping is more advantageous than a technology transfer at an earlier phase, i.e., component or subsystem development. The results of government laboratory prototyping must be in a form that facilitates a transfer of this experience to industry.

Single Source System Prototyping (A^1_{32}) - In this alternative, a single weapon system concept, selected from competing proposals evaluated during the Concept Exploration Phase, is demonstrated by designing and building a complete system prototype. Three factors establish this strategy:

- A single concept or solution to the problem was clearly superior to all others
- Urgency of need, physical and financial factors, or the lack of qualified industrial firms precluded multiple sources
- Perceptions of technical risks or desire for extensive user community participation warrants full system prototyping.

As in any single source effort, the lack of competitive influences must be compensated for by extensive government involvement in the management and technical direction of the program.

Multiple Source or Parallel System Prototypes (A^1_{33}) - This strategy has been the accepted mode of development for the past decade and referred to in the literature as a "Fly Before Buy" concept or system selection through competitive "fly-offs." This alternative can offer the government a near "hands off"

approach to system development, accrue the blessings of design competition, and offers the most definitive D&V effort. Technical risks, expected performance, reliability predictions, schedules, maintenance alternatives, and many other program factors are quantified based on tests and measurement of actual hardware rather than studies and analysis. The price of this definition is time and dollars. The competitive nature of this strategy tends to stretch out the schedule over the same effort conducted by a single source. The firms involved want to be in the best possible position for the demonstration and evaluation that selects the FSD contractor. In addition to the cost of a second D&V contractor, the government will incur further costs associated with additional support personnel, T&E facilities, and multiple contract negotiations.

2.3 FULL-SCALE DEVELOPMENT (FSD) PHASE

FSD is that period when the design of the system(s), demonstrated in previous development, and the peripheral equipment necessary for its support are subjected to further intense analysis and refinement to ensure the engineering or pre-production prototypes will meet their performance thresholds. Production and logistic concepts are updated and the system fabricated and tested. The FSD may generate one or many test articles depending upon the character of the program. These test articles are expected, at the least, to closely approximate the production configuration. They form the baseline for the system until the government completes a first production article acceptance test.* Further, the FSD should demonstrate the production readiness of the system in terms of design completeness; the company in terms of manufacturing and test facilities,

*See DAR 1-1900.

dition, and managerial capacity; and the planned
ort system in terms of its potential for meeting
vailability thresholds. Projected life-cycle cost
refined, and by DSARC III these must be compatible
ed funds.

gn completeness is reflected in both develop-
erational test (DT/OT) and a formal production
pection in accordance with DODD 5000.34. In
h a pilot production line is an integral part of
efinitive measure of production readiness is pos-
ction considerations include the quality and com-
drawings, production plans and controls, incoming
s test requirements, inspection and test methods,
cilities, industrial support, manloading and indus-
g, configuration and data control procedures, soft-
nt plans, jigs and fixtures, and the capacity to
gh volume of initial repairs and returns.

stic support concepts and plans and support-related
uation data are assessed to ensure that the system,
, will meet the operational availability goals
n the DCP. These are detailed in the Integrated
ort Plan (ILSP) as FSD progresses. Operational
is a single number index that relates system design
ility and reliability projections. The attributes
l availability include mean-time-between-failure
time-to-repair (MTTR), maintenance concept,
pecial support equipment design and quantity, sup-
on-board parts allowance, technical data, repair
ersonnel and maintenance training considerations,
rational and maintenance funding availability, etc.
also largely determine the operational and main-
of the system.

The program manager's insight into the technical risks associated with the design(s) demonstrated during Phase I, the urgency of need, and the adequacy of the projected R&D funding available to meet life-cycle cost goals during Phase II will influence the choice of FSD strategies. Basically, four alternatives are available and are displayed in Figure 2.3-1.

$$\begin{array}{lc} & \begin{array}{cc}\underline{\text{Single Firm}} & \underline{\text{Multiple Firms}}\end{array} \\ \begin{array}{l}\text{Incremental}\\[1em] \text{Concurrent}\end{array} & \begin{bmatrix} A^2_{11} & A^2_{12} \\[1em] A^2_{21} & A^2_{22}\end{bmatrix}\end{array}$$

Figure 2.3-1 Phase II Strategy Alternatives

2.3.1 The Concept of Concurrency

For lack of an accepted definition, concurrency may be characterized by the initiation of significant tasks directly associated with one acquisition phase prior to the completion of the previous phase. The end of FSD is usually marked by major reviews of the test results, the production plans by the DOD Component that developed the system, and a DSARC III hearing. Vagueness in definition arises from the fact that FSD may include a pilot or limited production line for test articles, and that the developing contractor must also demonstrate a readiness for production by satisfying an independent OSD review group. Many of these tasks indeed are related to production.

One may view concurrency at this stage of the acquisition process in terms of efficient resource utilization, particularly technical staff, with the objective of having a smooth

transition from FSD into production in parallel with the test and evaluation and subsequent DOD reviews.

To put this effort into perspective, it is not uncommon for the contracting actions associated with a major contract to require more than a year. An independent test agency will often require three to five months after the completion of the T&E to analyze the test data and report the findings and recommendations. The Service reviews and Decision Coordinating Paper (DCP) revisions may require four to six months. Once a service position is established, the preparation for the DSARC III may require another three to six months. Of course, some of these tasks can be done in parallel, but many others must be serial.

The degree of concurrency employed is a compromise based on the expected changes that higher authorities and review organizations may impose upon the program and the costs of early production changes that may result. Concurrency may vary from a small cadre contract to hold the contractor's technical staff together to a complete first lot order.

2.3.2 Incremental FSD by a Single Firm (A^2_{11})

Although not preferred by OMB/DOD policy because it no longer has an element of competition, this strategy is the norm in major weapon system development. The rationale most frequently presented for using a single firm is straightforward: the anticipated cost of paralled FSD coupled with the certainty that only one weapon system design will enter production, however capable the alternative system, strongly suggests that competition during FSD is not economically justified.

Further, there is significant long term planning, programming, and budgeting tasks that must take place early during

FSD to accomodate the introduction of a new weapon system. Overhaul and modification work packages; installation plans; weight and space reservations on new construction ships and aircraft; firm commitments for operational and maintenance training programs, devices, and facilities; the development of unique ground support, handling and test equipment; the creation and validation of operational tactical doctrine; the budgeting for personnel requirements and many other activities all are a function of the physical and performance parameters of the new system. Uncertainty of the ultimate choice of competing systems often delays these actions and certainly adds significantly to the administrative burden of the PMO and supporting organizations.

The rationale most frequently presented for incremental or serial FSD and production is equally straightforward: by clearly separating these two segments of the acquisition process, the short term government financial risks are confined to the effort at hand, i.e., FSD. This strategy allows the government time to test and re-evaluate the operational requirement and the effectiveness of the system under test, and to scrub the life-cycle cost and schedule projections used in planning. Time is provided to incorporate major changes in the engineering hardware by developmental and operational testing. Since there is little or no real commitment to production planning or tooling, a conservative image is presented to Congress.

2.3.3 Incremental FSD by Multiple Firms (A^2_{12})

This strategy is consistent with the overall intent of OMB policy to continue competition as long as economically feasible. If the anticipated production quantities are large, parallel FSD may be justified in order to provide a competitive environment for negotiating production contracts. A straight-

forward discounted cost/benefit analysis can indicate if the extra investment in a second FSD contractor could be recovered during the production phase. The impact of priced production options or a multiyear contract could also be assessed. By varying the inflation rates and/or the discount factor, the net financial loss or gain to the government could be examined for different future states of the national economy.

Parallel FSD may also be an appropriate alternative if technical risk is a significant factor that is carried over from earlier phases. This carry-over could result from skipping the D&V phase altogether or combining the D&V effort with FSD. Another possibility is that the D&V effort is limited in scope and serves to reduce the number of potential concepts, but has not selected one approach as clearly superior to all others. When technical risk is the motive for parallel FSD, it is often possible to establish an intermediate decision point, such as Milestone IIA, in which one concept and developer is selected to fill the need. This split phase approach can reduce the cost of parallel FSD if there is adequate data available upon which to base a decision on which contractor should complete FSD and enter production. The number of test articles developed and the test plan are strong factors in obtaining confidence in an early decision. The potential impact of this decision is significant.

2.3.4 Concurrent FSD and Production by a Single Firm (A^2_{21})

This strategy has as one of its overall objectives, the reduction of the total time to IOC by beginning some production tasks prior to the completion of development and operational testing (DT/OT III) and its subsequent review by the PMO, the developing DOD component and OSD. The decision to engage in concurrent FSD and production is made based on the urgency of

need, the agreement that the risks identified during the D&V phase can be reduced during FSD to an acceptable level, and that the program manager, rather than an independent test activity, may determine the readiness to initiate production related tasks. The formal completion of FSD and the subsequent DSARC III hearings to enter production confirm the PM's decision based on the persistence of the operational requirement, the systems effectiveness as measured by an independent test agency, and the plans for production. The objective of concurrency is to buy as much time as possible with the least obligation on the part of the government.

When the government employs an incremental strategy, the developer phases down his technical staff as FSD draws to a close. In most cases the developer must charge key personnel to company overhead or reassign them to other programs during the twelve to eighteen months that are typically required to test and evaluate the system, determine what modifications must be made to resolve deficiencies, prepare and issue an RFP, and negotiate a contract.

Concurrency can save up to thirty-six months in some programs, but at the risk of some obsolesence in supply parts due to subsequent system changes. In general, concurrency will increase R&D costs since some production tasks are accomplished during FSD. Initial support costs tend to be higher due to configuration changes directed as a result of Phase II test and evaluation. Production costs are reduced, however, due to efficient use of the FSD technical team and generally better personnel management.

2.3.5 Concurrent FSD and Production by Multiple Firms (A^2_{22})

This strategy has the advantage of time compression, but at the expense of both dual FSD and preproduction tasks.

If the rationale for parallel FSD is to reduce technical risk or to acquire sufficient additional data to make a system selection, an iterim decision point may be established. By shifting from a parallel FSD (A^2_{12}) to concurrent FSD by a single company (A^2_{21}) some reduction in program cost would be possible.

If the intent of parallel FSD is to provide a price competition for production, an interim decision point could be counter productive. If the rival firms were required to bid on a production contract before FSD was completed and the system/source selection was to be based significantly on bid/negotiated price, a price auction may result.

The use of this strategy would be under circumstances in which the competitors are building essentially the same end item and the government has a production rate requirement that would justify parallel or co-production (e.g., to satisfy wartime production surge requirements or to provide redundancy in production facilities).

2.4 PRODUCTION PHASE

The selection of an acquisition strategy for production is made in an ambivalent DOD policy environment that simultaneously stresses competition, efficient production delivery rates, economies of scale, reduction or elimination of superfluous specifications, imposition of standardization, the accomplishment of socio-economic goals, maintaining the appearance of fairness, buy American requirements, and NATO Rationalization, Standardization, and Interoperability (RSI).

As a matter of practicality, it is usually necessary to reduce all rival weapon system concepts to a single system

for production. It is redundant and extremely expensive to maintain a training and logistic support base for two systems that accomplish essentially the same task.* To that end the alternatives for production are centered around one system and the experience acquired by its developer. Six general strategy alternatives are available, and they are displayed in Figure 2.4-1.

$$
\begin{array}{ccccc}
 & \underline{\text{Initial Production}} & & \underline{\text{Subsequent Production}} & \\
A^3 = & \begin{bmatrix} A_1^3 \\ A_2^3 \\ A_3^3 \\ A_4^3 \\ A_5^3 \\ A_6^3 \end{bmatrix} & \Rightarrow & \begin{bmatrix} A_n^3 \\ A_2^3 \\ A_3^3 \\ A_{4,6}^3 \\ A_5^3 \\ A_n^3 \end{bmatrix} & \Rightarrow \begin{bmatrix} A_n^3 \\ A_n^3 \\ A_n^3 \\ A_{4,6}^3 \\ A_5^3 \\ A_n^3 \end{bmatrix}
\end{array}
$$

$$n = 1, 2, 3, 6$$

Figure 2.4-1 Phase III Strategy Alternatives

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*During the transition period from an old weapon system to a new one, the DOD Component must maintain a manpower, training, supply parts and repair program for both systems. If the transition period is long, the cost of these parallel support activities alone would, in many cases, justify increasing the production rate of a new system to replace the old system faster, thus eliminating one support program. (It should be noted that in some cases, the logistics support base for an old weapon system continues for FMS customers. We are still maintaining F-86s, F-84s, and C-47s for foreign customers, but on a fully reimbursible basis.)

2.4.1 Production by a Single Firm Without Priced Options (A_1^3)

This is one of the two alternatives most often employed by DOD weapon system managers. Virtually all major weapon systems are complex and represent state-of-the-art technology. Consequently, the developer is usually the only industrial source that is qualified to enter into production. With this alternative, significant technological advances can be made in a weapons development even if the DOD Component lacks the scientific and engineering capacity to bring it about. The knowledge and experience accrued by the developer during and prior to FSD is utilized during the initial production without the intervention or significant support of the government. The developer turned producer effects an internal transfer of information from one phase to the next.

Usually when a stand alone production contract is negotiated without options, the intent is to limit the obligation of the government in an environment of technical or economic uncertainty. This uncertainty could be in many forms:

- Total inventory requirements are unknown
- Market prices for both labor and materials are volatile and expected to be significantly different in the future
- To require an option price for future quantities would require the contractor to incur undue risk

- The program is politically sensitive and may be revised by OSD or Congress.*

The initial production contract, if quantities are relatively small, may represent the entire government requirement. If additional quantities are envisioned, other strategies may be considered that would be advantageous to the government.

2.4.2 Production by a Single Firm with Priced Options (A_2^3)

This alternative is the second most common procurement technique used by DOD in large system acquisitions. It has the advantages of alternative A_1^3, discussed in the previous paragraph, in that the government does not have to participate in the transfer of technology and information between FSD and production, i.e., the developer makes this information transfer. Where government requirements are known at the time of initial production award, and the cost exceeds the funds available in a given year, price competition may be extended to subsequent years through the use of priced options. If price competition is to be used in selecting the initial production contractor, the DAR† specifies that option quantities may be offered without limits on the price. In some circumstances, however, the production RFP may stipulate that option quantities may be offered at

*When a contractor offers a priced option which may or may not be exercised at some time in the future, he usually incurs certain costs in ensuring he will be able to fulfill the option if called upon by the government. Typically, these costs are included in the price of the basic contract. A contract for a specified number of end items plus a priced option for an additional number of end items will usually cost the government more than a contract for the specified number of end items alone without any options.

†DAR 1-1502.

prices no higher than those for the initial production quantities.

The contractor is aware that the government has the right to unilaterally exercise or forego an option at the time agreed to in the contract. Therefore, the contractor must structure his bid to accommodate both cases, i.e. the basic contract and the options. During the period of performance of the basic contract, he must assure he will be able to acquire the necessary materials and labor to fulfill the options if called upon by the government. In most cases, this means negotiating option quantities with vendors and subcontractors. They, in turn, incur certain costs and risks in ensuring they will be able to fulfill the options if called upon. These costs are typically reflected in both the price of the basic goods and the price of the option quantities. This cost increase is often acceptable to the government if it constrains the cost of subsequent buys that may otherwise be negotiated sole source to that producer.

2.4.3 Multi-Year Production Contract with a Single Firm (A_3^3)

When the requirements of the government are generally known and funds are not available to buy the inventory objective under a conventional contract, a multi-year contract (MYC) may be an appealing alternative to priced options. Under a MYC the government is obligated to buy the total quantity agreed upon over a period of years.

The contractual obligation by the government removes some of the business uncertainty from the procurement, allows the contractor to amortize his non-recurring tooling and facilities costs over the period of the contract, and allows the

contractor to negotiate firm piece part or subsystem quantities with subcontractors and vendors. A multi-year contract reflects the learning curve effect of the total procurement into a price competition. An economy of scale can be realized.

This alternative offers many advantages over a priced option contract, but there are important restrictions on its use that must be fully evaluated. The DAR* specifies that the contractor is protected against loss resulting from cancellation by contract provisions allowing reimbursement of unrecovered non-recurring costs included in the prices for cancelled items.† However, the cancellation ceiling, or a maximum amount that the government will pay a contractor in the event of cancellation, may not be in excess of five million dollars unless the Congress, in advance, approves such a cancellation ceiling. This means that all the contractors' non-recurring costs, less five million dollars, must be absorbed in the first contract year.

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*DAR 1-322.1.

†Note that cancellation as used when discussing a multi-year contract is not synonymous with termination. Both terms are operative concerning a multi-year contract. The contracting office may terminate a contract for the convenience of the government. In such cases the government is obligated to compensate the contractor for certain losses associated with the termination, e.g. work in progress, obligations to vendors, etc. The government may also terminate a contract for cause. In this case the government voids the contract due to non-compliance with the terms, conditions, or schedule on the part of the contractor. If sustained, the contractor would bear the financial loss.

Cancellation occurs whenever funds are not available to continue the remainder of the multi-year commitment. In this case, the cancellation procedure spelled out in the DAR and the contract are made operative, and the government must establish a separate vehicle for further procurements when funds are available.

A well structured MYC would recognize the non-recurring costs of establishing production, the projected learning curve effect, inflation, and statutory cancellation requirements, and would provide provision to accomodate events outside the control of either the procuring agency or the contractor.

This alternative (A_3^3) can lower costs to the government through work force and supplies stability, provide an element of standardization in that all end items required over a multi-year period are provided by a single prime contractor, and avoid annual administrative reprocurement, non-recurring, and requalification costs associated with annual contracts that could go to different prime contractors.

A MYC provides a means to spread over the life of the contract the very high start up costs that usually inhibit competition. To accomplish this with the restrictions of the cancellation ceiling requires innovative contracting techniques.

2.4.4 Leader/Follower (A_4^3)

As defined in the Defense Acquisition Regulations: "Leader company procurement is an extraordinary procurement technique under which the developer or sole producer of an item or system (the leader company) furnishes manufacturing assistance and know-how or otherwise enables a follower company to become a source of supply for the item or system." The rationale for using this strategy is to achieve one or more of the following objectives:

- Increasing the delivery rate of the weapon system or end item
- Establishing additional sources of supply for reasons such as geographical dispersion or broadening the production base

- Making maximum use of scarce government-owned tooling or special equipment

- Assuring uniformity and reliability in equipment performance, compatability or standardization of components, and interchangeability of parts by charging a single prime contractor with configuration control responsibilities that are not amenable to some other solution

- Effecting an efficient transition from development to production and to subsequent competitive procurement of the end items or of major components.

The last objective, the introduction of competition into the production phase, has received considerable attention by the architects of defense systems acquisition policy.*

The DAR lists three logical government-leader-follower contract relationships:

- Award a prime contract to an established source (leader company) in which the source is obligated, by the terms of the contract, to subcontract a designated portion of the total number of end items required to a specified subcontractor (follower company) and to assist the follower company in that production. Using this approach the prime or leader company has certain contractual obligations that tend to elicit a reasonable effort towards supporting the subcontractor (follower). The degree of support is, of course, based on the leader's perceptions of future awards and the role the follower may play as a competitor. Note that since the award is to the leader, a price competition does not exist

*Hearing before the House Armed Services Committee, 12 February 1980.

Award a prime contract to the leader company for a designated quantity of end items plus a task for the requisite assistance to the follower company. A separate prime contract is awarded to the follower company for production of the items. Although an element of competition may exist, the follower company is very much at risk in that it must rely to a significant extent on the assistance of the leader. As in the first arrangement, the leader's cooperation and support is a function of the terms of the contract and the perception of the follower as a competitor for future awards.

Award a contract to the leader company for a specified number of end items. Award a second prime contract to the follower company for some quantity of end items Under this contract the follower company is obligated to subcontract with a designated leader company for the requisite manufacturing and technical assistance.

e a significant price competition seldom exists the three arrangements describea, this strategy dered a prerequisite for competition -- a means of second firm to participate in a meaningful price or as a means of meeting mobilization goals.

principal difficulty in implementing a leader act is to achieve the necessary degree of cooperathe developer turned leader and follower who will rn competitor. Typically, a technology transfer e by a technical data package alone, and the deve- the instrument of information and experience transernment must find an incentive for the leader that is perceived sole source negotiation position and operation. Should the incentive payments approach expects in a sole source environment, he will no te. This does, however, reduce cost savings to t resulting from competitive production sources.

If a leader/follower concept is contemplated for production, appropriate steps should be taken in negotiating the FSD and initial production contracts to ensure that the leader will possess the necessary production skills and resources to furnish assistance to a follower company.

Leader/follower techniques have been successfully implemented when the objectives were other than price competition. The Korean conflict and the sense of urgency associated with the "cold war" of the early 1950s prompted several companies to provide manufacturing assistance to competitors to accelerate the delivery of combat aircraft to the government.* Further, both the Air Force and the Navy have had success in establishing dual sources of supplies to meet mobilization objectives.

2.4.5 Technology Licensing (A_5^3)

Technology licensing, often referred to in the literature as direct licensing or separation and licensing is a strategy in which the firm (or organization) that performs the FSD would agree, as a condition of full-scale development, to license any other company so designated by the government for the manufacture of all or some specified portion of the end item or system developed. The developer may or may not be a producer.

The underlying reasons for selecting a licensing strategy affects the terms and conditions of the FSD and production contracts and will determine the complexity of the program, its cost and probability of success.

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*Carter, Gregory A., "Directed Licensing: An Evaluation of a Proposed Technique To Reduce the Procurement Cost of Aircraft", Rand Report R-160-PR, 12-74, (AD A007064).

Should the objective for licensing be defense mobilization, this alternative is similar to a leader/follower contract in which the developer awards a subcontract to a qualified firm designated by the government. Since there is no price competition, the prime contractor can include his perceived risk in the negotiated contract.

If the objective for licensing is to generate a price competition for the end item, the terms, conditions, and requirements of the appropriate contracts must be exceptionally well defined. The difficulties with this approach are identical to those of a competitive price oriented leader/follower contract. The government must find an incentive for the developer that will offset his perceived sole source negotiation position and elicit his cooperation.

By way of comparison, in attempting to penetrate foreign markets, a U.S. firm will license a foreign company to manufacture a product if it believes that the policy of the nation in question precludes direct sales of U.S. goods. In other cases, in which the labor market and tax structure is favorable, a company may prefer to license rather than export. This is not the case in the U.S. domestic military market. In all likelihood, a developer would enter into a licensing agreement with the government only if he lacked the capacity to produce the end item in the quantity rate desired or if adequate incentives were provided.

If the objective of a licensing program is to meet U.S. national goals in an international arena, the contractor may be required to conform to an inter-governmental memorandum of agreement and assume risks, over and above domestic contracts. In these cases, contractor cooperation comes at an added price.

In times of national emergency when the demand for weapons exceeds the manufacturing capacity of a company, various forms of cooperation are freely given. In other times, a firm will tend toward establishing and maintaining a dominant market position and will be reluctant to support a price competition.

2.4.6 Second Sourcing (A_6^3)

Second Sourcing, sometimes referred to as follow-on competitive procurement, is a strategy in which a weapon system is acquired from a source other than the developer and/or the original manufacturer.

The decision to establish a second source is often based on economics -- the expectation that price competition will ultimately lower unit costs -- and entered into with the understanding that a return on the investment of a second source may not be realized for many years, depending upon when the second source is introduced.

Under this concept a technical data package (TDP) consisting of drawings, specifications, and in some cases the end item itself is the vehicle of technical transfer. The developer, other than providing the TDP in the form specified by the government, is not involved. The program office purchases, verifies through system engineering and configuration audits, and subsequently provides in an RFP, data comprehensive enough to allow qualified firms to make a proposal. The initial selection of a second source supplier is based on technical competence, performance records, facilities and generally factors other than price. The first contract is usually a limited "learning quantity" awarded for the purpose of gaining experience and providing hardware that can be used for qualifying tests. Following procurements are expected to be

priced competitively between the original producer and the second source.

Once the TDP is delivered to the government, it is necessary that a qualified technical staff ascertain if the data describes the system, if it is complete, and if it is in sufficient detail to allow an end item to be produced based primarily on this information. This verification process cannot be accomplished if the basic design is unstable, i.e., being modified by engineering changes either directed by the government or proposed by the current manufacturer.

In approaching a potential second source, the government must warrant the completeness and adequacy of the TDP and direct that the second source "build to print." The government will accept whatever performance is achieved. Conversely, the government may direct that the second source build to a performance specification and use the TDP as a guide. In this mode, the second source will undoubtedly re-engineer the system to understand its performance parameters. In most cases, the configuration of the end item will differ between manufacturers. Although a form, fit, function and performance criteria may be met, the potential for increased logistic support costs and future complications due to engineering changes must be balanced against competitive savings.

Because of the problems associated with technology transfer, verification of data, and the government liabilities when warranting TDP completeness, the most successful second sourcing efforts have been medium to low technology, self contained (few interfaces) programs in which the government requires large quantities of items over an extended period. Typically, the items are also expendable. Missiles, rocket motors, and sonobuoys are examples.

2.5 INTEGRATION OF PHASE ELEMENTS

The desire to explore alternative means of meeting a mission need, to minimize technical or schedule risk, or to reduce the production or life-cycle costs are reasons for encouraging and tolerating different system configurations during the three pre-production phases of the acquisition cycle. However, the life-cycle costs associated with supporting two (or more) complex weapon systems usually militate against parallel production of competing end items. The extra logistic costs associated with providing stock numbers, purchasing, stocking, repairing, and documenting a second weapon system are usually prohibitive, particularly if in-house support is used.

For items limited to a single configuration, competition during initial production and subsequent procurements can be achieved through second sourcing, leader/follower contracts, or licensing agreements. Items that meet a form, fit, and function criteria may justify parallel production if the economic advantages of competition offset the logistic costs of multiple end items.

Economic factors aside, if a compelling reason exists, any phase alternative can be made to follow any of the alternatives associated with a prior development phase.

3. INFLUENCING FACTORS

The significant factors and considerations influencing acquisition strategy were derived from the literature search coupled with interviews with program managers and their staffs, contracting officers and their support groups, comptrollers, and acquisition policy organizations within the services and in OSD. The factors described in this chapter were each considered to be significant in the selection of a development or production alternative by at least two sources.

As the factors were collected they were separated into the following nine categories:

- Time
- Inventory Objective
- Government Resources
- Contracting
- Policy
- Urgency of Need
- Industrial Environment
- Cost
- System and Technology.

Following this grouping, each factor was rated as to the effect it has on a particular phase of the acquisition cycle. The convention adopted is as follows:

1. A major, direct influencing factor
2. A minor, direct influencing factor. In combination with other factors, it can become major
3. A direct factor (either major or minor) only at extreme values; otherwise not usually significant
4. An indirect factor (i.e., it influences other factors
5. May be a direct factor depending on the previous phase alternative
6. Affects the scope of work within a phase alternative and will affect subsequent alternatives

Given these groupings and factor ratings, tables within the subsequent sections of this chapter display the results of this factor classification. Each factor is classified according to its effect in each of the following acquisition phases:

- $\emptyset_{O}$ -- Concept Exploration
- $\emptyset_{I}$ -- Demonstration and Validation
- $\emptyset_{II}$ -- Full-Scale Development
- $\emptyset_{III}$ -- Initial Production and Deployment
- $\emptyset_{IIIB}$ -- Subsequent Production

For example, the lead time for contracting actions is classified as a 1 (a major, direct influencing factor) during $\emptyset_{II}$, FSD, and as a 4 (an indirect factor) during $\emptyset_{III}$, Initial Production and Deployment.

It should be emphasized that both the classification of the factors and the associated ratings are completely subjective. Although several possibilities were considered before arriving at the methodology presented, both the classification and the ratings should be considered as a preliminary formulation subject to change with further research. The primary importance of the current formulation is that the factors have been identified, they have been segmented into logical groupings, and they have been rated in a manner which attempts to incorporate the collective assessment of the numerous individuals interviewed. They thus comprise a suitable formulation for demonstrating feasibility and preliminary model development. The remainder of this chapter discusses each factor and its influence individually.

3.1 TIME

3.1.1 Discrete Budget Year Factor

Funds are provided annually based on requests by the program manager which were established two and a half years earlier through the PPBS process. This request for funds is considered along with similar requests by the program manager's parent command, material/system command, and Service headquarters staff. Subsequent review by OSD and OMB finalizes the President's budget including DOD's position concerning the funding needs for each acquisition program.

In administering a developmental program, a need for money to support discrete tasks rarely occurs precisely at the time funds are available. This mismatch varies from a minor

TABLE 3.1-1
TIME FACTORS

Factor	Effect				
	ϕ_0	ϕ_I	ϕ_{II}	ϕ_{III}	ϕ_{IIIB}
Discrete Budget Year Factor	1	1	1	1	
Concept Exploration Time		1			
Lead-Time for Milestone Decisions			1	4	
Lead-Time for Contracting Actions			1	4	
Demonstration and Validation Time		1			
GFE Schedule	1	1	1	3	
Lead-Time for Test Resources		1	1	2	
Opportunity Time for Test Resources		1	3	2	
Developmental/Operational Test Time		1	2	2	
Full-Scale Development Time			1		
Long Lead Material Acquisition Time		1	1	1	
Total Production Time	3	3	1	1	1
Production Rate	3	3	1	1	1
Continuous Production Requirement			1	1	1
First Article Availability Time				1	1
Technical Data Package Verification Time				4	1
Second Source Qualification Time			1	4	1

inconvenience to a major restructuring of the program. The non-availability of funds usually requires the reduction of planned efforts in one phase and rescheduling the task for a later date. The net result is to carry forward uncertainties, problems, or risks to the next phase of the program. This carry over does affect the choice of subsequent strategies.

3.1.2 Concept Exploration Time

The time budgeted for concept exploration (and indeed all developmental phases) is based on the anticipated annual level of future funding and the urgency of need. Funds available at the program's inception, the number of months remaining in the fiscal year, and anticipated funding the following year can strongly influence, and even dictate the choice, of concept exploration strategies.

3.1.3 Lead-Time for Milestone Decisions

The time between the completion of a developmental phase and the decision rendered at a DSARC review varies from six months to over a year depending on the urgency of the program. This review period must be accommodated in the program plan and steps taken to ensure continuity of key personnel and efficient use of resources.

When the review time is expected to be extensive, a strategy that employs some degree of concurrency is a reasonable alternative.

3.1.4 Lead-Time for Contracting Actions

The total time from initial draft of an RFP to a completely negotiated contract can run well over a year. The system testing, review, approvals, funding actions, and contract-

ing actions are highly interdependent. A network analysis is required to properly assess the impacts of a contract action on an overall acquisition strategy and to suggest alternatives consistent with the urgency of need, remaining technical risks, and available funds.

3.1.5 Demonstration and Validation Time

The urgency of need, perception of technical risk, and available funds dictate the choice of a demonstration and validation strategy. This acquisition strategy element is essentially a delineation of the scope of work and the application of resources expected to reduce technical uncertainties to acceptable levels. The time to complete the Demonstration and Validation Phase is also a function of the choice of strategies.

3.1.6 GFE Schedule

When the determination is made that a new development will incorporate government furnished equipment as an integral portion of the overall design, the delivery schedule of the GFE then has the potential of pacing the development cycle and strongly influencing the production plan. The Department of Defense historically is adverse to procuring and then storing systems. The slower schedule, either GFE or prime equipment, usually dominates acquisition plans.

3.1.7 Lead-Time for Test Resources

Various development programs and fleet/field training requirements compete for scarce test resources. The time required to identify and assign a test platform, squadron, or user group to a development program can cause either a delay in completing the planned test cycle or the deletion of some

tests. In either case, the next phase of the program would be influenced by the change in the test programs.

In some cases a complete lack of some test resources may require the parallel development of test tools. The tools themselves require some degree of validation which adds to program schedule uncertainties.

3.1.8 Opportunity Time for Test Resources

Although some test resources are totally dedicated to R&D programs, others are not (e.g., test ships and squadrons). These are usually assigned to a program subject to higher priority operational constraints; operational deployments and major training exercises take precedence. Seldom are these resources available long enough to accomplish all the desired tests. Uncompleted tests transfer uncertainties into the next phase of the program and can affect the choice of strategies.

3.1.9 Developmental/Operational Test Time

The magnitude of the test effort is specified in the Test and Evaluation Master Plan (TEMP). The availability of resources and the quality and number of test personnel assigned determine the time necessary to complete the developmental and operational test. In addition to planning and executing the test, the results must be analyzed, documented, and briefed to decision makers. The net result of the test program and the time required to reach a milestone decision influence the work to be accomplished in the next phase.

3.1.10 Full-Scale Development Time

Full-scale development represents the most inclusive of all phases of the developmental cycle and usually takes the longest time. The end result of FSD is an assessment of the readiness of the system to enter production, its operational effectiveness, and its supportability. The measurements that usually precede the DSARC III review and subsequent program decision are lengthy and often accomplished with little participation on the part of the developer. Should the length of these tasks, when considered with other time consuming activities, threaten the integrity of the contractor's design team or otherwise jeopardize the program, a change in acquisition strategy is likely. This shift is often towards a single source and some degree of concurrency.

3.1.11 Long Lead Material Acquisition Time

The lead time to acquire some critical materials or subsystems may dictate some degree of concurrency or otherwise pace the schedule of the program. Items like nuclear reactors have to be placed on order well over a year prior to the award of a shipbuilding contract. In effect, some financial risk is accepted in order to shorten the acquisition cycle.

3.1.12 Total Production Time

An estimate of the total inventory requirement and the rate of consumption will provide an approximation of the maximum production time. The length of this period will indicate whether sufficient time is available to establish a credible second source. If not, price competition will be unlikely and the entire acquisition cycle will be structured accordingly.

Production Rate

uction rate or consumption rate is a determinant
strategy. A demand rate in excess of a developers
ests a parallel producer -- a low rate would sug-
manufacturing company but would offer the oppor-
elop a second source.

Continuous Production Requirement

desire for a continuous production capability is
sustained consumption and/or high start-up costs
lf-life. This is a relatively straightforward
trol problem. If start up costs are low, the
a second source and price competition exists.

wartime mobilization rate is the motive, the
cepts the dis-economies, if any, associated with
lternative production sources and low utilization
during peacetime.

First Article Availability Time

test and acceptance of the first article is re-
ure that the contractor can produce an end item
with the contract specifications before, or in,
age of production. This test is always required
apon system and may be applied to preproduction,
ction, test samples, or pilot production products.
the DAR part 1-1900 is to demonstrate contract
ior to a large financial commitment by the govern-
the contract specifies that the materials purchased
first article approval are at the risk of the

Once the first article is shipped to a government laboratory for tests, the contractor may be obliged to sit and wait for an unspecified period before he can resume his pre-production effort. This unproductive period is a function of government test resources, priorities, and most important, the terms and conditions of a production contract.

The method of accomplishing a first article test will affect both the production price schedule and the potential for establishing a second source.

3.2.16 Technical Data Package Verification Time

The technical data package is the primary medium of technology transfer when attempting to establish a second production source. The sequence of events that lead to a data package are:

- Defining and then specifying the level of detail required
- Negotiating the purchase of the data package
- Creating it once a stable design is achieved
- Verifying its accuracy and completeness.

The time required to accomplish these tasks is dependent upon the quality and availability of government personnel to review, specify, and later verify both the data package and the stability of the design. Realistic system maturity projections based on observed performance during full-scale development and the first article test will provide an insight into when and if a second source is possible.

3.1.17 Second Source Qualification Time

Once an acceptable data package is available and verified, the government may begin establishing a second source. A production-capable firm is selected based on appropriate criteria and awarded a small contract. The intent is to underwrite the second source's learning process and to qualify his initial product. This education contract is seldom placed in competition with the developer, but viewed by the government as an investment to be recovered through a future price competition.

The time required to create a price competitive environment may be too long to meet other program constraints.

3.2 INVENTORY OBJECTIVE

3.2.1 Firm Requirements

The known inventory requirement of an end item is significant in the development of an acquisition strategy. A one-of-a-kind command-and-control system may not justify competition other than during the concept exploration phase. The requirements for several thousand missiles may justify parallel FSD and co-production if a single configuration is selected. The inventory objective and the estimated unit cost form the basis for many cost/benefit judgments in program planning.

3.2.2 Contingent Requirements

Requirements in excess of those considered firm are classified as contingent requirements. For example, systems for ships or aircraft not yet authorized by Congress, or estimated consumption rates not yet validated by usage patterns fall into this category. In most cases, contingent require-

TABLE 3.2-1
INVENTORY OBJECTIVES

Factor	Effect				
	$\emptyset_0$	$\emptyset_I$	$\emptyset_{II}$	$\emptyset_{III}$	$\emptyset_{IIIB}$
Firm Requirements	3		1	1	1
Contingent Requirements	3		1	1	1
FMS Requirements	3		1	1	1
NATO/3RD World Requirements	3	2	1	1	1

ments are not used as a primary input to a cost/benefit analysis, but are subsequently used to test the sensitivity of quantities to different development or production strategies. Decision techniques involving probabilities are appropriate.

3.2.3 FMS Requirements

Foreign military sales' requirements are normally considered as contingent requirements. Usually firm orders from foreign governments are not known in sufficient time to play a significant part in the establishment of an acquisition strategy. However, once these requirements become known, they will influence subsequent production considerations.

3.2.4 NATO/Third World Requirements

NATO and Third World requirements would normally be treated as contingent requirements similar to foreign military sales. However, if the U.S. enters into a joint program in which a consortium of governments jointly develops and produces a system, the quantities required by each NATO nation form the

basis for their share for funding the developmental costs and for negotiation of a possible overseas production portion of the program. In many cases the acquisition strategy becomes a multi-dimensional negotiation between nations, U.S. contractors and foreign nations, U.S. contractors and foreign suppliers, and U.S. government and U.S. contractors. This development program may involve not only the Department of Defense but the Department of State and the Department of Commerce.

3.3 GOVERNMENT RESOURCES

3.3.1 PMO Staffing

The experience, knowledge, and numbers of civilian and uniformed personnel assigned to the Project Office dictate

TABLE 3.3-1
GOVERNMENT RESOURCES

Factor	Effect				
	$\emptyset_0$	$\emptyset_I$	$\emptyset_{II}$	$\emptyset_{III}$	$\emptyset_{IIIB}$
PMO Staffing	3	3	3	3	3
Laboratory/Engineering Center Expertise	1	1	4	4	
Availability of Laboratory Support	1	1	4	4	
Test Facilities		1	1		
PM's Plant Representatives			4	4	4
DCAS/DCAA Support				2	2
GFE/GFM/GFI	1	3	3	1	1

the level of direct involvement of the government in the acquisition process. The Office of Manpower and Budget civilian personnel policy, as it is applied to DOD components and the subordinate commands, establishes a civil servant pay grade and numerical ceiling against which the PMC's parent command allocates personnel positions. The perception of importance or priority of the program dictates staff level potential. In a similar manner, the perception of importance establishes and fills military billets.

The state of the economy, as it effects that segment of the private sector concerned with defense systems, strongly influences the willingness of professionals to accept government employment. An expanding economy, coupled with limits on civil servant pay grades, can leave authorized positions vacant indefinitely.

3.3.2 Laboratory/Engineering Center Expertise

The range and depth of knowledge of a laboratory or engineering center in a particular field of technology are almost always a function of that laboratory's charter to engage in basic research and exploratory development, or of its participation in a current weapon system development program that involves similar technology. Each laboratory or engineering center has basic research and support responsibilities against which their personnel are charged. Nonetheless, a significant portion of the laboratory's annual budget must be customer-provided. Specifically this means that, like industry, a laboratory must continue to solicit support tasks and obtain project funding to maintain a minimal level of competence and flexibility. With a large number of support programs, a laboratory may generate enough slack resources to accommodate a new program with minimal delay. More often, the laboratory will experience the same problems of acquiring knowledgeable pro-

fessionals as does the PMO. Again, priorities, either self imposed or established by the DOD component, may dictate the reallocation of laboratory personnel to support one program at the expense of another.

The use of laboratory expertise by a project office falls into three broad categories:

- The direct assignment and integration of laboratory personnel into a program office. In this case the program manager negotiates directly with the laboratory for the quality and quantity of personnel and the period of performance
- The use of a laboratory to accomplish a specific task. This approach is similar to a commerical contract, in that a statement of work, period of performance, negotiated payments, and deliverables are agreed upon by both parties
- The use of a laboratory for consulting efforts. Participation in source selection boards, technology assessments, program reviews, etc., are illustrative.

3.3.3 Availability of Laboratory Support

Although a laboratory may have the expertise required to augment a project, these resources may be committed to other favored or more interesting programs. The allegience to a parent command may cause a laboratory to support in-house efforts at the expense of higher priority programs administered by other commands. On occasion, a lower priority program which promises long-term stable project funding may take precedence over a more important program with limited tasks.

3.3.4 Test Facilities

The availability of test resources is often a critical element in a program's overall schedule. Some scarce resources are available on a priority basis, others are available on a discontinuous or intermittent basis. The combination of priorities and discontinuous availabilities can extend a program's completion and subsequent IOC dates several years. For example, the availability of a ship or an aircraft in which to install a new system for test may be based on operational deployment schedules, modification schedules, crew training requirements, and upkeep needs. Once installed, priorities for other test resources -- test ranges, target drones, tracing radars, etc. -- must be compatible.

In some cases, certain tests are not practicable. In others, new test facilities must be established or constructed to meet test needs.

3.3.5 PM's Plant Representatives

In the execution of a major development and acquisition program, the program manager has a need for continuous on-site representation within the company's facility. This is usually accomplished by assigning one or more members of the project management office to this task. Several procedural issues must be resolved:

- Creation of an officer billet and subsequent assignment of a qualified person to head the effort. This is a function of the Service's perception of the program's importance.
- Resolution of inter-service jurisdictional problems and specific tasking. When a company has several DOD contracts awarded by different Services, only one Service

provides overall liaison between the contractor and the government. For example, AFPRO/Hughes GSD serves both Air Force and Navy project offices with contracts at Hughes Aircraft Co., Fullerton, California

- Delineation of the PM representative's authority -- is he a liaison officer, a contracting officer's technical representative (COTR), or an administrative contracting officer (ACO).

3.3.6 DCAS/DCAA Support

The support provided the program manager by the Regional Defense Contract Administrative Service (DCAS) and the Defense Contract Audit Agency (DCAA) is, in part, a function of a negotiated memorandum of agreement between the program manager and DCAS. However, both the DCAS and the DCAA are separate organizations with independent funding and personnel ceilings. The extent of specific support is often a matter of persuasion on the part of the program manager rather than direct tasking or control. The program manager often must work his program needs in with other programs at a particular plant with DCAS. Since many administrative functions are accomplished more effectively by DCAS and DCAA, the program manager usually accepts some compromises. Note that most contract actions require some DCAS/DCAA participation. Their responsiveness greatly affects schedules.

3.3.7 GFE/GFM/GFI

It is the policy of DOD components to break out for separate development major subsystems that may be used in different applications. Aircraft engines, mini-computers, and command and control displays are examples. When the government directs a developer to use GFE, the rationale is usually based

on economies of scale with respect to the government-provided equipment.

In many cases, however, late delivery or configuration changes in GFE adversely affect the performance of the development/production contract, and can be used as the basis for a constructive change claim. At the least, it could affect the program's schedule and cost.

When systems are being developed to meet a changing threat environment, or to interface with evolving systems, the quality and timeliness of government-furnished information affects contract performance.

3.4 CONTRACTING

3.4.1 Bidders List

The initial bidders list should indicate to industry which companies the program manager believes to be most capable of satisfactorily participating in a development or production program. Often the program manager is at odds with existing socio-economic policy which encourages small and disadvantaged businesses to participate in government programs.

A program manager should not encourage a company to bid if that company is clearly not competitive; conversely, any company that wishes to provide a proposal has every right to expect that his proposal will be read and fairly considered. The program manager must deal equitably with all bidders and still maintain his program schedule.

TABLE 3.4-1
CONTRACTING FACTORS

Factor	Effect				
	$\emptyset_{0}$	$\emptyset_{I}$	$\emptyset_{II}$	$\emptyset_{III}$	$\emptyset_{IIIB}$
Bidders List	1	1		1	
Requests for Proposal	1			1	
Proposal Evaluation		3	1		
Risk Management		1	1	2	
Contract Type			6	6	
Share Lines/Target/Ceiling Price			6	6	
Fee			6	6	
Data Rights	2	2		1	
Incentives			6	6	
Cost Accounting Standards		2	2	2	
Performance Measurement Systems			2	2	
Contract Administration			6	6	6
Protest/Legal Action		1	1	1	

3.4.2 Requests for Proposal

The RFP is a principal instrument of communications between government and industry in establishing what must be done subject to specified constraints. It is difficult enough for the project management office to delineate the scope of developmental tasks. The effort grows increasingly complex as the program nears production. The review and approval cycle of a RFP provides ample opportunity for staff personnel to interject their favorite positions into the solicitation. Left unchallenged, the RFP can grow to be the algebraic sum of

everyone's preferences -- and quite unaffordable. Since the staffing of a major RFP may require well over a year, the program manager must be selective in the issues he challenges. Otherwise the staffing actions may swamp the program schedule.

3.4.3 Proposal Evaluation

Prior to issuing an RFP the program management office must establish a source selection plan that will select both the system to be developed and the proposing firm. Concepts, rather than cost, predominate during the first two phases of development. Costs become increasingly more important from FSD throughout the remainder of the program. The RFP and the evaluation plan must capture the government's preferences in terms of phase cost, life cycle cost, system performance, and schedule. Since it is unlikely that a unique bidder will propose the best, cheapest, and quickest with credibility, the source selection plan must provide a means of balancing these factors. The importance of these parameters, properly conveyed to industry, should have a significant impact upon the architecture of the development efforts.

3.4.4 Risk Management

The methods of managing risk vary. Provisions within the contract, slack schedules, program management reserve funds, and alternative plans are means of coping with uncertainty. Political constraints usually dictate the most acceptable methods of managing risks.

3.4.5 Contract Type

The type of contract reflects a program manager's and the government's attitude concerning the priority of the program, perception of risks, contractor's profits, and future

business. High-risk development contracts are usually of the cost reimburseable type; low-risk contracts tend to be fixed price. Should a contractor not share the government's perception, his feelings are reflected in his bid price. For example, the government may view a particular contract as low risk and opt for a firm fixed price contract with options. On the other hand, the contractor may view the task as a medium technical risk project in a volatile economic environment and raise his bid accordingly.

3.4.6 Share Lines/Target/Ceiling Price

In many contracts, financial risk is shared in an agreed-upon manner. For example, in a FPI (cost) contract, the government may pay all cost up to an agreed upon target; additional costs are shared by the government and the contractors subject to a negotiated schedule up to a ceiling. At the ceiling, the contract becomes a firm fixed price (FFP) with the contractor bearing all future costs. Because this type of contract is perceived as being fair, it is often used in full-scale development and first production contracts. This contract type not only shares risks but allows for a price competition not feasible in a cost reimbursible type contract.

Note that the current trend in FPI contracts is toward lower ceilings and lower government sharing of costs over target. Currently, in over 80 percent of such contracts, the government's share of costs over target is 75 percent or less, and ceiling prices now average about 119 percent of target compared to 123 percent a few years ago.

3.4.7 Fee

The contractor's bid price includes fee. The expected fee is a function of the contractor's expected risk -- the more

risk, the more fee. Changing the risk share arrangements could reduce the contractor's negotiated fee position. However, in an effort to induce industry to perform in a desired manner, negotiated fees now average a little over 12 percent compared to just under 11 percent two years ago.

3.4.8 Data Rights

The equitable resolution of data rights is a complex problem. Most firms engage in some form of research and development. They hope these efforts will enhance their market position. When new technology is proposed as a basis for a new system development, the bidder expounds on the multiple advantages of his approach while attempting to maintain legal control of the information or process. The government tries to acquire unlimited rights to the data to enable an out-year competition. There are examples in the literature where companies decline to bid based on the data rights clauses in an RFP. Contracts should be structured to clarify all data rights issues.

3.4.9 Incentives

The government attempts to elicit certain performance or behavior from a contractor through the use of well structured incentives. While profit, sales, cash flow and continued business are easily recognized, an appeal to patriotism or the threat of being disqualified from a competition have also been used. A recognition of a company's long-range objectives can improve the quality of incentive programs. This is particularly true when the government would like a firm to behave in a manner not in the company's best financial interest. Inducing a firm to participate in a technological transfer designed to create a second production source requires great finesse on the part of the government.

Cost Accounting Standards

: accounting standards required to do business wth ıt of Defense are seldom of concern to large corp- ıey may offer problems to small or 8(a) businesses › penetrate government markets. Although the proj- ıay initially provide a waiver, a persistent lack : accounting standards could severely delay the contracts or require a new solicitation altogether. ıdequate accounting standards by subcontractors ıally affect the strategy element, but could affect ıce of that stage of development. An approved cost :andard system is necessary if the contractor de- ›s payments.

Performance Measurement Systems

ıalified management information system which meas- : performance in terms of budget, schedule, and :tors is required on all DOD programs designated .tions, and strongly encouraged on other programs. can insist that the same contract performance :riteria be imposed on critical subcontractors major program.

absence of a validated information system seldom :hoice of an acquisition strategy element, but it ı contract award and affect a negotiated cost. a system that conforms to the criteria delineated 2 can be expensive; these costs are usually passed ernment in some way.

3.4.12 Contract Administration

The ability to properly administer a contract is a function of the cooperation and resources of the project management office, the parent command, the contracting officer, and DCAS. In the absence of adequate resources, the project manager tends toward a program in which competitive forces compensate for the lack of in-depth government guidance and supervision.

3.4.13 Protest/Legal Action

An efficient acquisition program must conform to a schedule in which previously budgeted funds are applied to a specific work task. Events that disrupt that schedule are to be avoided.

Many firms invest heavily in a proposal. Losing a near-term contract could foreclose significant future sales. It is not surprising that the perception of unfairness could prompt an official protest or the initiation of legal actions that would disrupt the program's schedule. To that end the that could convey to industry the impression of bias, or of being arbitrary and capricious.

3.5 POLICY

3.5.1 The Importance of Competition

Public law and tradition have established a policy over the last two hundred years of open competition for public funds. The Defense Acquisition Regulations stress formal advertisement and sealed bids as a preferable approach to acquiring goods and services for the government. OMB/DOD policy directs

TABLE 3.5-1
POLICY OR POLITICAL FACTORS

Factor	Effect				
	$\emptyset_0$	$\emptyset_I$	$\emptyset_{II}$	$\emptyset_{III}$	$\emptyset_{IIIB}$
Importance of Competition	1	1	2	1	1
Mobilization				1	1
NATO/RSI	1	2	3	1	
Socio-economic Factors	1			1	1
Congressional Interest		1	1	1	
OSD/OMB Interest		1	1	1	
Timeliness	1	1	1	1	
Freedom of Information Act	4	4	4		
Desire for Innovative Procurement			1	1	3

that competition be made an integral part of every major acquisition program as long as feasible. The perception that competition has social merit, will reduce costs, and enhances the appearance of fairness and equity, are all factors in the design of an acquisition strategy. The decision to "establish" a second source is often made on the basis of this policy rather than economic conditions alone. The degree to which policy makers insist on competition drastically affects every phase of an acquisiton program.

3.5.2 Mobilization

Although price is the principal reason for most competition, the need to maintain an industrial base and/or disperse manufacturing functions throughout the nation often prompts the establishment of alternative suppliers of critical

goods. Accommodating both price competition and mobilization goals may be achieved by establishing a second source -- often these objectives are incompatible. Many defense industries and potential competitors are located in the same geographical area; a significant number of defense contractors are located in Boston, South Bay San Francisco, and Los Angeles.

3.5.3 NATO RSI (Rationalization, Standardization, Interoperability)

In accordance with PL94-361, it is a policy of the U.S. government that equipment procured for U.S. forces stationed in Europe under the terms of the North Atlantic Treaty should be standardized, or a least interoperable, with equipment of other nations of NATO. Further, during concept exploration phase, the possibility of using NATO weapon systems or European suppliers are to be considered along with U.S. based alternatives. Compatibility with NATO's systems could include metrification or other physical standardization procedures. A closer involvement with NATO nations in a joint development agreement could call into play foreign disclosure issues, joint testing considerations, international patent protection, international contract administration, source selection problems, etc. Domestic and international development programs differ vastly in their administration and management procedures.

3.5.4 Socio-economic Factors

Government socio-economic programs must be considered throughout the systems acquisition process. Particular emphasis is to be placed on contracting with small and disadvantaged business firms; DOD policy encourages the use of small and innovative contractors during the concept exploration phase of systems development. In complying with this policy, small businesses and 8(a) programs play an important role as a sup-

plier or vendor; however, they often lack the breadth of management or financial stability to function as a prime contractor. In cases where the basic technology of the concept being considered for development is proprietary to a small business, some joint venture or licensing agreement must be established. More significantly, when a major weapon system uses a proprietary component or subsystem as an integral part of its design, the prime contractor and the government must have the right to build the device should the small business not survive. Further, the program manger must make allowances in the program's schedule and budget when several untried small businesses are integral to the development or production program. Many small businesses are both capable and experienced; however, a number are founded on a technically innovative or creative concept and are undercapitalized and directed by inexperienced management.

3.5.5 Congressional Interest

Characteristic of a major weapon delevelopment program is the expenditure of large amounts of public funds. Aside from the usual reactions to DOD expenditures, real differences over the wisdom of a particular weapon development often arise within the committees and subcommittees of Congress. At times conflicting guidance from subcommittees make the intent of Congress difficult to follow; further, project support within Congress varies from year to year. A program manager can expect that Congress will influence the direction of the project either through direct guidance or indirectly through appropriations.

3.5.6 OSD/OMB Interest

In a similar manner, the professional staff of OSD and OMB variously reviews, supports, and opposes a particular program. The staff of OSD is not homogeneous, and a position

at any given time is at best a negotiated one and is subject to change at the next review. Program funding is not directly related to DSARC guidance; an approved program must compete for funds with other projects in the annual PPBS process. Budget Analysts and Financial Managers can be more significant than acquisition policy planners to a program's survival.

3.5.7 Timeliness

A goal of any major DOD weapon acquisition is to achieve an initial operational capability (IOC) within the time dictated by the need or the threat. When financial, technical, or logistic risks are low or when the need to counter a specific threat transcends technical or cost considerations, the program manager should seriously consider minimizing the acquisition cycle by employing concurrency. Further, increasing funding, overlapping, combining, or at times omitting developmental phases of the acquisition process, or overlapping and combining the developmental test and evaluation with the operational test and evaluation, could minimize the acquisition cycle time. The degree of concurrency should be a balance between potential savings of acquisition time and financial risk. A project manager may also institute a program of planned performance improvement. This concept envisions a managed performance improvement program after the system has been initially deployed.

3.5.8 Freedom of Information Act

Although serving the public in many areas, the Freedom of Information Act has had a chilling effect on some government/industry relations. Many companies are reluctant to provide documentation concerning their proprietary research efforts, financial stability, biographies of key personnel, or other

pertinent information to be used by the government in the system or source selection process. For a little more than the cost of postage, a company may request and often get a competitor's proposal and access to proprietary information. Revised DOD policy guidance and/or current litigation may remove some uncertainties in the handling of what was once considered priviledged data. At the present, fear of disclosure to competitors often inhibits open communication with the Defense Department.

3.5.9 Desire for Innovative Procurement

The continuing belief that innovative acquisition techniques will remedy some of the inefficiencies documented in the past has established a variety of procurement and system acquisition concepts that carry not only the form of legitimacy, but are actively encouraged by proponents within the Department of Defense. Design-to-cost, life-cycle-costing, and reliability improvement and failure-free warranties are directed or at least actively supported in DOD policy documents; contract definition is not addressed, total package procurement is specifically prohibited by the DAR.

3.6 URGENCY OF NEED

3.6.1 Reprogramming Actions

The perception of need within the Headquarters activity of the developing DOD component and the relative program priority among competing programs are reflected in the command's willingness to reprogram R&D funds to support the first one or two years of many programs (until the PPBS process can catch up). The actual dollars available during the concept exploration phase of a program effectively dictate the scope of work or

TABLE 3.6-1
URGENCY OF NEED/PROGRAM PRIORITY

Factor	Effect				
	$\emptyset_0$	$\emptyset_I$	$\emptyset_{II}$	$\emptyset_{III}$	$\emptyset_{IIIB}$
Reprogramming Actions	3	3	3		
PPBS/POM Support		4	4	1	
User Command Support			1		
Test Resources		4	1		
Master Urgency List		4	4	4	
DCAS/DCAA Support			2		
Material/System Command Support	4	4	4	4	
Logistics Command Support		6	6	6	6
Personnel and Training Command Support		6	6	6	
Operator/Maintainer Acceptance		6	6	6	6
Laboratory/Engineering Center Support	1	2	3	6	
Deviation from Specifications and Standards				2	
Deviation from Policies and Procedures		1	1	1	

scale of activity in which the program manager may engage. Subsequent reprogramming action is necessary to accommodate changes of scope, inflation, and new requirements. More to the point, inadequate reprogramming would require a descoping of the development effort and/or a postponement of scheduled activities.

3.6.2 PPBS/POM Support

The Headquarter's Command of the DOD component must annually allocate fiscal resources to meet its development and production needs. Through an iterative staffing process, the Service eventually arrives at a program funding level consistent with SEC DEF guidance and the relative importance of the program. After the funding levels are established, all programs are ranked in accordance with the perception of importance. The need for the system -- as reflected in the collective staffing of the DOD component, JCS and OSD -- ultimately establishes a fiscal resource level that constrains a program manager's options and alternatives.

3.6.3 User Command Support

The command that will ultimately employ the weapon system influences, to a greater or lesser degree, the conduct of the program. In many cases, the user command provides a continuous input of preferences, desires, operational constraints, and tactical concepts that assist the program manager in his value judgments. Occasionally the system configuration will deviate so drastically from conventional systems that the user command becomes uncertain or even hostile to the concept. The program manager needs the command's advice and support, but he must also maintain an arm's length distance; the user commands often want system enhancements or specific features that are not part of the original requirement document or DCP. The program manager may exceed his authority in implementing a user command's desires if not approved by higher authority.

3.6.4 Test Resources

Short of field/fleet tests in actual combat, a new weapon system is tested in an artificial environment. The

degree to which the test environment approximates the real world is usually limited by practical considerations. It is not practical to gather large numbers of ships together to simulate a major war-at-sea scenario just to test one weapon system -- nor is it economical to recreate the electromagnetic environment in which an airborne command post will operate. Instead, the test environment attempts to exercise the new system in those areas where major deviations from expected performance could be significant.

In most cases the DOD test resources are used by many R&D Projects, major system modification projects, tactics development, and major joint exercises or training efforts. The program manager must vie for priority and schedules to maintain his discrete project schedule. Often he is competing not only with his own Service but also with other Service's projects for preferential scheduling.

3.6.5 Master Urgency List

Within the Department of Defense and Department of Commerce is a system that establishes a priority for filling piecepart orders and the allocation of critical materials based on national security considerations. Under the authority of federal law, a vendor may be directed to fill an order for a particular defense contract ahead of a commerical order or other defense programs. This priority system is called the Master Urgency List (MUL). The priority of a weapon system program -- as seen by the developing Service and DOD -- is reflected in a project being included on the MUL and in its standing on that list. Without this support, the negotiating skills of the prime contractor and the economies of the market place can greatly affect the expected completion date of an R&D or production program.

3.6.6 DCAS/DCAA Support

The Defense Acquisition Regulations delineate approximately 100 functions automatically accomplished by DCAS unless the tasks are specifically withheld by the procuring agency. The relationship between the procuring agency, the project manager, the contracting officer, the regional officer in charge of DCAS, and the administrative contracting officer is established in a joint memorandum of agreement. Since DCAS is independently funded and must operate within its allocated personnel ceilings, they assign their own internal priorities. The timeliness of audits by DCAA -- a precursor of the contract award or modification --or the authorization for overtime for QC inspectors can pace the program schedule. The program manager's alternatives are few. He may withhold tasks from DCAS; however, their functions must be accomplished by his own organization which may suffer from the same resource limitations as DCAS. Of concern to the program manager is the relatively small influence he can exert over the establishment of DCAS and DCAA priorites that directly affect the outcome of his program.

3.6.7 Material/System Command Support

Since few project managers have adequate manpower authorizations to completely staff their offices, a matrix management organization of some type is usually required. The perception of importance, or urgency of need, as seen by the program's parent command is reflected in the pay grade, the numbers of assigned personnel, and the authorization for new hire positions. This perception of importance is also reflected in the responsiveness to direct program tasking of the other functional departments or divisions within the parent organization. Most system commands provide contracting, legal,

and comptroller services independent of the project management office.

3.6.8 Logistics Command Support

The logistics commands operating within their respective Service charters are generally responsible for the quality and quantity of repair parts, their administration, stock, and distribution. The operational effectiveness of a weapon system is a function of the quality of logistics support. Many decisions made by the technical staff of the project management office during the developmental cycle will ultimately affect the ease or difficulty and the cost of logistics support. The active support of the logistics command in providing historical logistic overhead rates, logistic trends, cost effective procedures, and other pertinent guidance will assist in design value judgments. Early cooperation between logisticians and developers will facilitate subsequent transitions of responsibility.

3.6.9 Personnel and Training Command Support

An overall objective of all new weapon system programs is a reduction in the number of personnel required to operate and maintain the system, and a reduction (compared to the system being replaced) in the amount of training that is necessary to achieve the desired level of readiness. On the other hand, the commands responsible for recruiting, training, and managing the uniformed personnel are often required to offer extensive technical training as an inducement for enlisting in the service. The objectives of the program manager to keep the system simple could be at odds with the personnel and training command requirements. A meeting of minds is necessary for orderly development, production and deployment of any system.

3.6.10 Operator/Maintainer Acceptance

The community of technicians that will ultimately operate and maintain a new weapons system have a vested career interest in a configuration of that system. Professional pride and post-service employment opportunities prompt the demand for in-depth technical training; in-service career goals tend to reject large scale parts substitution and depot repair maintenance concepts.

Supervisory personnel at higher pay grades may be reluctant to see large changes in applied technology that could jeopardize their position of authority. The transition from analog to digital circuitry and from vacuum tube to solid state technology was accepted grudgingly by many Service career fields.

The program manager must mount an effective indoctrination program with the user career fields if he is to expect broad-based field/fleet support for a weapon system employing new technology. This effort can be expensive, in both PMO time and money.

3.6.11 Laboratory/Engineering Center Support

Government laboratory and engineering centers are, to a greater or lesser degree, customer funded by weapon development projects and special programs. The ability and/or willingness to support a particular project is reflected in the laboratory's perception of that program's importance in the amount of annual long-term funding that program will provide the laboratory the opportunity to expand into related technology areas, and whether the program is consistent with the laboratory's image. Like industry, the laboratory must smooth intermittent requests for technical support into a stable annual level of effort.

3.6.12 Deviations from Specifications and Standards

Current DOD directives encourage the tailoring of acquisition programs, the prudent imposition of military specifications and standards, the use of commercial equipment, and the acceptance of contractor information systems where possible. Conformance to this guidance is unemotional during the concept exploration and the demonstration and validation phase of development. As the program enters full-scale development and production it is extremely difficult and time-consuming to obtain reviewing authorities approval for an RFP that deviates significantly from military specifications. Although there is general agreement that many specifications are applied improperly, few functional staff members will agree to lowering or modifying the specification to reflect a unique application. Highly visible programs or programs of great urgency do not encounter the same level of resistance as routine programs. The extent to which advocates of specific specifications and standards must defend their use on a program versus the PM having to defend why they are not appropriate varies with the program.

3.6.13 Deviations from Policies/Procedures

When a program is known to have Congressional, DOD, or Secretarial interest, it is relatively easy to tailor an acquisition strategy, combine documentation requirements, and in general, structure a program to meet a unique situation. This is not at all the case in a less visible program; staffs require rigid adherence to the directives, instructions, notices, specifications, standards, policies, and procedures in force at that time. The responsibility to prove cost and time savings at minimal program risk is the program manager's; in many cases the time and effort required to prove cost effectiveness associated

ng these requirements to the program negates the

degree of support or opposition to a concept within anization and parent command will strongly influence e of an acquisition strategy.

TRIAL ENVIRONMENT

Technology Base

arge investment with a low probability of return strains the number of U.S. firms engaging in advanced The number of major weapon systems being developed tment of Defense at any one time seldom exceeds and fifty (150). Taken together it is not sur- so few high technology DOD oriented firms enter e market place. Further, it is to be expected am manager's choice of qualified industrial firms te in a development program will be limited. Spe- he U.S. weapons industry is not an unconstrained

Industry-Wide Economic Conditions

general economic conditions affect the quality of industrial firms willing to participate in a f Defense program. Further, the conditions affect id and negotiation strategy and their ability to tal expansions and to acquire skilled workers. If economy is in a recession or the economic picture gloomy for this particular segment of industry, ill probably be lower in hopes of capturing a long s base. On the other hand, if times are good and

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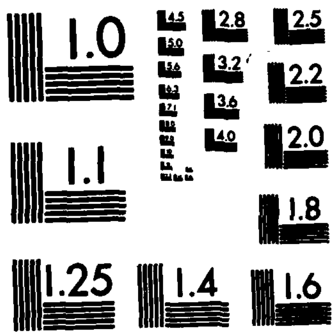

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

TABLE 3.7-1
INDUSTRIAL ENVIRONMENT

Factor	Effect				
	ϕ_0	ϕ_I	ϕ_{II}	ϕ_{III}	ϕ_{IIIB}
Technology Base	1	2	5	1	1
Industry-Wide Economic Condition			1	1	1
Company's Intermediate and Long Range Objectives	1	5		1	1
Understanding the Warfare Discipline	1				
Understanding User Preferences	1				
Understanding Environmental/ Operational Constraints	1		2		2
Perception of Competitive Position	4	4	4	4	1
Contractor's Perceived Risk	4	4	4	4	1
Company's Backlog of Orders	4	4	4	4	1
Commercial Potential		4	4	4	1
Availability of Skilled Personnel	4	1	1	4	4
Anticipated Future Requirements		4	4	4	1
Contractor's Required Investment		4	4	4	1
Make/Buy Considerations				1	1
Availability of Work Space/ Critical Tools/Material	3	1	1	4	1
Subcontractor/Vendor Availability		3	3	2	1
Integration Skills			4	1	1
Production Capacity		3	3	1	1
Proprietary Data			6	1	1
Area Wage Rate			3	3	3
Overhead/G&A Rate			3	3	3

industry expects ample business, the bid prices will be higher if that industry tends to be indifferent to the acquisition of new government business.

3.7.3 Company's Intermediate and Long Range Objectives

The short range objectives of a firm strongly influence their willingness to participate in a government program; their long range objectives strongly influence their bid prices. The desire to maintain a certain commercial/government product mix can have either a positive or negative impact on a bid price. A strong desire to enter a high technology market will tend to reduce the bid price and create an environment for a possible buy-in. Future expansion plans will also influence price, usually toward the low side. A minimum return on investment requirement will probably increase the bid price in the short run.

3.7.4 Understanding the Warfare Discipline

If an industrial firm is to create a hardware solution to a military deficiency, that firm must have a comprehensive understanding of the warfare discipline in question. It is not enough to be a high technology hardware house, the firm must fully understand the interplay between other weapon systems, sensors, tactics, rules of engagements, etc. A sound technological solution may not be an acceptable military solution.

3.7.5 Understanding User Preferences

The needs, desires, preferences, and cultural biases of the end item user must be appreciated if an industrial firm is to be successful in the design and ultimate fielding of a new weapon system. This understanding must go further than a

superficial examination of style or physical factors; it must acknowledge the expectation of the user in terms of a natural extension of the weapon systems with which he is familiar. Significant changes from the expected must be accomplished gradually with considerable user/designer dialogue, generally through the PMO.

3.7.6 Understanding Environmental/Operational Constraints

The quality of trade-offs associated with an effective and affordable system design is a direct function of the developer's understanding of the physical and operational environment in which the system must operate. The physical environment is made up of shock, temperature, vibration, humidity, and other parameters; the operational environment includes the tempo of operation, sortie rate, electromagnetic environment, standby time, and factors that effect the use rate or the cycle time of the system. The program manager must choose a developer knowledgeable of these factors or provide sufficient time and money within his program to educate the developer.

3.7.7 Perception of Competitive Position

A firm's perception of its competitive position has a strong influence on the composition of the proposal team and the company's bid price. If the company was the full-scale developer or the initial production company, his bid price will probably be high. If the government establishes a second source that can provide a price competition, the bid price will be lower. A contractor's manufacturing capacity also affects bid price. Too much excess capacity requires that overheads be allocated to a small product line, thus driving the bid prices up. At the same time, the need to expand production to absorb overhead costs can work toward a downward adjustment in price. The age of manufacturing facilities,

tooling, and test equipment can indicate higher cost if equipment is inefficient or obsolete. Area wage rate differentials and union agreements also affect bid price. A strong union may force a higher price due to higher wages and increased cost of benefits. Wage rates vary throughout the country. If a firm is located in an area where wage rates are high, this tends to raise the bid price.

3.7.8 Contractor's Perceived Risk

A company's risk is of two types, financial and professional. A company will go to great lengths to achieve and maintain a reputation of professionalism in their prime field of endeavor. This extends to accepting a short term financial loss when it is inevitable. Financial risks come in many forms; bid and proposal money, redirection of qualified personnel for proposal preparation and early design efforts, new hires in anticipation of a contract award, keeping key people on overhead during test and decision periods, accepting fixed price FSD and initial production contracts, accepting options during volatile economic conditions, and capital investments are only a few. These risks strongly influence the contractor's negotiating position.

3.7.9 Company's Backlog of Orders

When a company has a backlog of orders, he may neither seek nor be willing to accept government business. If he is the only firm that can reasonably accomplish the task, the government must bargain from a position of weakness.

3.7.10 Commercial Potential

If a system, subsystem, or component of a weapon development has commercial potential or substantial FMS or direct

overseas sale potential, a company may elect to bid low or even buy-in in an effort to secure future business.

3.7.11 Availability of Skilled Personnel

Skilled personnel are difficult to acquire on a short notice and may even be impossible to hire in time to meet an agreed upon schedule. At this time, software architects, computer programmers, and systems integration engineers are at a premium, and companies actively pirate them from their competitors. At other times the shortage varies from skilled production workers to professional engineers. Most companies must build up a staff and then tear it down to meet the man loading requirements of an ideal program. Usually work-arounds and schedule slippages occur due to critical personnel shortages.

3.7.12 Anticipated Future Requirements

Many firms base the bid price on quantity in excess of the basic quantities expressed in the RFP. The greater the anticipated future requirements, the lower the bid price. The possibility of initial spares purchase, installation support tasking, field support, refurbishment, or depot repair tasking also tends to lower the initial bid price of the end item.

3.7.13 Contractor's Required Investment

The government normally requires a firm to provide all the resources necessary to comply with the terms and conditions of the contract. This means that the firm must have the facilities, tooling, test equipment, expertise, documentation, and labor required if it is to be considered a credible competitor. To be in a position to bid, a firm must be well financed. Cash flow problems could be a deterent to competition.

A firm may not be able to acquire sufficient capital to commence and sustain a development or production effort.

3.7.14 Make/Buy Considerations

If the developer and initial producer is primarily a systems integrator -- that is, the weapon system is largely assembled from components built by subcontractors or vendors to a developer's specification -- the potential for price competition is small. The reason is twofold. The technical documentation package procured to serve as a technology transfer medium is seldom as detailed as the subsystem specification negotiated with the vendor. Further, the skills and methods used to integrate the components into a unified system are rarely well documented. However, the most important factor is that the lion's share of system dollars are passed through to subcontractors. The prime contractor controls only the fabrication, test, G&A, and fee. This represents about 30% of the end item cost and does not provide the prime contractor with much room to negotiate.

3.7.15 Availability of Work Space/Critical Tools/Materials

Even if a bidder is amply financed, he may be unable to acquire the work space needed to properly execute the contract. Many firms find that a system developed in one location must be manufactured at another because the original site is inadequate and cannot be expanded. This presents the developer with a technology transfer problem not too different from a conventional second source. Seldom will the original design team elect to move to the new manufacturing site.

The move to a different manufacturing site could also be required in order to share critical tooling.

The lack of critical materials is a joint government/industry problem. Usually industry is overly optimistic regarding their ability to acquire materials; the program manager is usually slow in his efforts to establish a priority with the Department of Commerce. The net result is often a schedule slippage.

3.7.16 Subcontractor/Vendor Availability

In most modern weapon systems development, the subcontractors and vendors are the agents of most technological advances. Usually the prime contractor establishes his components' specifications based on a dialogue and negotiation with several vendors that are engaging in a technological rivalry. At the outset the prime may have a wide range of suppliers to choose from -- however, once the selection is made, the prime may find that he has been forced into a sole source position. In some cases the subcontractors hold proprietary rights to the components. This situation further limits the prime contractor's options.

As a general rule, subcontractors/vendors press the state-of-the-art, provide materials and services to several vendors and are themselves one of many competitors. Vendors and subcontractors are seldom as vulnerable as the prime contractor to the effects of a program cancellation. On the other hand, a subcontractor must maintain a stable business base through technological innovation and aggressive marketing.

3.7.17 Integration Skills

With increasing weapon systems complexity, the systems engineer or system integrator is becoming a dominant figure in engineering and manufacturing activities. This individual(s) must not only integrate diverse technologies --electronic,

mechanical, thermodynamic, computer sciences --but also ensure that physical components are compatible. Of significance is his ability to preceive a third or fourth order impact of a proposed engineering change. System integrators are much in demand; experienced system integrators are at a premium. Without a skilled integration staff, most major weapon programs will not meet their expected performance or schedule.

3.7.18 Production Capacity

A firm's production capacity directly affects bid price. Slack capacity drives up overhead rates. Insufficient capacity requires capital expenditures, inefficient subcontracting, or parallel production at different locations. An ideal situation is one in which the contractor can absorb new business within the facilities available. Any other circumstance would tend toward increasing the bid price.

3.7.19 Proprietary Data

A subcontractor or vendor maintains his market position through technological innovations usually supported by company funds. Prime contractors also support large industrial research and development programs aimed at capturing future markets. Often a firm will be unwilling to give or sell its rights to the government. In this case the government must find another technological solution or be content with a sole source situation.

More often, the government attempts to buy proprietary data but lacks the ability to fully describe what is desired. As a result, the government has some information but a second production source must still accomplish a great deal of re-engineering in order to build the end item. In these cases, the

initial production and subsequent production lots are usually a different configuration.

3.7.20 Area Wage Rate

The prevailing economic conditions of a geographical location strongly affects the area wage rates and consequently the product bid price. The industrial northeast and California tend to be several percentage points higher than the sun belt. To be competitive, a firm at a higher wage area must make offsets in negotiated fee or affect other efficiencies.

Higher area wage rates also indicate a higher cost of living. Food, housing, taxes and other economic conditions also affect the willingness of a professional to relocate to a certain area.

3.7.21 Overhead/G&A Rate

The accounting system used by a contractor can greatly affect the bid price. The distribution of direct and indirect charges, an actual or allocated system of funding shop materials, the difference between bid and negotiated subcontractor prices, internal vs. actual shop standards, cost sharing between healthy and not-so-healthy programs, and many other practices commonly accepted by industry can affect the bid price five to ten points.

3.8 COST FACTORS

3.8.1 Program Management Office Cost

Program Management Office cost is a relatively minor annual cost that (in some program offices) competes for a portion of the program's annual R&D funding. Manpower authoriza-

TABLE 3.8-1
COST FACTORS

Factor	Effect				
	$\emptyset_0$	$\emptyset_I$	$\emptyset_{II}$	$\emptyset_{III}$	$\emptyset_{IIIB}$
Program Management Office Cost	2	2	2		
Program Support Cost		2	2	1	
Administrative/Source Selection/Pre-Award Audit		2	2		
Concept Exploration Cost	1				
Demonstration and Validation Cost		1			
GFE/GFM/GFI Cost	2	2	2	2	2
Full-Scale Development Cost		1	1		
Contractor Investment Cost		1	1	1	
Maintenance and Operating Training Cost		6	6		
System Integration Cost		1	1	6	
System Installation Cost		6	6	6	
Contractor Field Support Cost				3	
Tactical Doctrine Development Cost		3	1		
Personnel Cost	3	4	5	4	4
Training Equipment/Services/Support Cost		6	6	6	
Proprietary Data Cost				1	1
Initial Spares Cost			6	6	
Non-Recurring Production Cost			1	1	1
First Contract Quantity				2	
Learning Curves				1	1
Unit Cost (Mid Point of Lot)				1	

TABLE 3.8-1 (Continued)
COST FACTORS

Factor	Effect				
	$\emptyset_0$	$\emptyset_I$	$\emptyset_{II}$	$\emptyset_{III}$	$\emptyset_{IIIB}$
Technical Data Package Cost				1	1
Technical Data Audit and Verification Cost				2	
Provisioning Data			6	6	1
Support Equipment Cost			6	6	1
Transportation Cost				3	1
Logistic Management Cost				6	1
Test Equipment Maintenance and Calibration Cost		6	6	6	1
Staff/Command Training Cost			6	6	
Technology Transfer Cost, Developer				1	1
Technology Transfer Cost, Second Source				1	1
Non-Recurring Production Cost, Second Source				1	1
Learning Curve, Second Source				1	1
Educational Buy Qualification Cost				1	1
Value of the Educational Buy				1	1

tions, or the authority to hire program staff, is more important than the cost of personnel.

3.8.2 Program Support Cost

Program support costs compete with other work package costs for annual R&D funds during the development phase. Support is provided by O&M funds during production. As a general rule, O&M funds are harder to justify than R&D. The lack of these funds may cause the re-orientation of a support program and the government's participation in program development and production.

3.8.3 Administrative/Source Selection/Pre-Award Audit

This is a relatively minor cost associated with the award of a contract. It is a factor to consider when making a cost/benefit analysis assessing the economics of a second production source.

3.8.4 Concept Exploration Cost

The funds available to initiate concept exploration limit the scope and choice of alternatives for this phase. The program manager must distribute his available funds between his program staff, the program support, and the competing firms that will participate in the concept exploration effort.

3.8.5 Demonstration and Validation Cost

The D&V Phase alternatives have a wide range of associated cost and schedule parameters. The funds available to the program manager will tend to limit his choice of alternatives. Further, once an alternative has been selected, the available funds will constrain the contractor's scope of work

and the funds allocated to the PMO, the support group, and the test program.

3.8.6 GFE/GFM/GFI Cost

This represents the cost of government-provided resources. These costs can be substantial. The case of a government furnished engine to an airframe manufacture is illustrative. The program manager must also fund these costs. In most cases the program manager has no direct control over the cost or delivery schedule of GFE, even though it is a major factor in the outcome of his program.

3.8.7 Full-Scale Development Cost

This is the most comprehensive development phase and the most expensive. The cost of competitive FSD varies, but generally is about 225% of the expected cost of a single developer. The additional cost represents a tendency to stretch out competitive FSD and the increased cost of a competitive test and evaluation program. Of course, available funds limit the FSD alternatives and the scope of work within the alternative.

3.8.8 Contractor Investment Cost

This is the cost a firm must bear as the price of participating in a program. It includes the cost of the bid and proposal, the opportunity cost of reassigning key personnel to a proposal effort, the cost of a qualified accounting and information management system, and the cost of personnel, facilities and expertise needed to be competitive. If successful, the bidder may recover some or all of the costs. If not, they constitute a business loss. The inability to bear these expenses

keeps many small companies from participating in government programs.

3.8.9 Maintenance and Operator Training Cost

The program manager is responsible for the training of the maintenance and operator personnel engaged in the test and evaluation effort. He must also fund and provide for the training materials, aids, and initial cadre training for the training command.

The guidance provided the developing firm can significantly affect the cost of ownership. A system designed for easy maintenance and operation will lend itself to economical training.

It should be noted that the program manager has little reason to expend his limited resources to enhance maintainability over and above that necessary to meet DCP thresholds or Service acceptance. Out-year training costs are not the program manager's responsibility.

3.8.10 System Integration Cost

This is a cost associated with the development and production of complex systems. Generally the cost and time needed for system integration efforts are underestimated by the contractor and unappreciated by an inexperienced PMO.

3.8.11 System Installation Cost

This is a cost of ownership which can be reduced if properly considered during the development process. Like training costs, the program manager has little or no responsibility for the costs after the test installation.

3.8.12 Contractor Field Support Cost

Most new systems require the support of the developer during the transition period from initial production to general use. The program manager budgets and funds these efforts. The quality and quantity of field support may affect the number of user requested ECPs.

3.8.13 Tactical Doctrine Development Cost

Although the program manager does not necessarily fund the development of tactical doctrine, he has a vested interest in the tactical employment of the system during the operational test program. Often the program manager will invest in an intense, small-scale, tactics development effort.

The PMO must, however, ensure that those organizations within the respective Services whose responsibility include tactical doctrine development are aware of the capabilites and limitations of the developmental system. This places another demand on the PMO's time.

3.8.14 Personnel Cost

The costs for operating and maintenance personnel after the system is placed into operational use are not charges to the program office, but they are an important consideration during the design effort and a major factor in source selection if life cycle cost is significant.

3.8.15 Training Equipment/Services/Support Cost

Although the program manager is not usually responsible for the development of training devices, this effort cannot proceed without the cooperation of the PMO. This activity places

another demand on the PMO's time. If not properly coordinated, the training devices may be ineffective, expensive, or both.

3.8.16 Proprietary Data Cost

This is the cost of obtaining unlimited rights to data created at private expense. This is necessary if a second production source is contemplated and the government did not finance all the developmental work. In cases where the developer will not sell his rights, leader-follower or licensing may be attempted if the government must have multiple production sources.

3.8.17 Initial Spares Cost

The cost of initial spares is usually budgeted by the program manager through the logistics organization of his parent command. He may also administer these funds. This task requires a knowledgeable logisitics manager assigned to the program office. Initial spares are hard to justify because usage data is unavailable. Initial spares are expensive because they are bought in small quantities and subject to becoming obsolete due to early ECPs.

3.8.18 Nonrecurring Production Costs

These costs represent a significant part of production costs which should be considered when conducting a cost/benefit analysis to determine the economies of parallel production or the feasibility of a second production source.

3.8.19 First Contract Quantity

This is the number of end items procured by the first contract. This quantity determines the type of tooling and the

mix of labor and automated production equipment. Small quanities cannot justify a large investment in production tooling.

3.8.20 Learning Curves

Learning curves are also loosely referred to as cost improvement curves, experience curves, cost-reduction curves, manufacturing-time forecasting curves, Wright curves, Crawford curves, and Stanford-B curves. Each of these terms is an expression of the notion that costs decrease as learning or experience increases.

Costs may be expressed in actual dollars or in the basic elements of cost; i.e., direct labor hours and units of material.

These costs are a function of the degree of automation used in production tooling and test equipment.

Projected learning curves give insight into the costs of systems subsequently procured from this firm.

3.8.21 Unit Cost (Mid Point of Lot)

This is the cumulative average unit cost of the lot. It is used to establish an apparent experience curve of a company.

3.8.22 Technical Data Package Cost

This is the cost of creating, to a government specification, a technical data package of sufficient quality to establish a second production source. This cost is a factor in determining the economy of a second source.

3.8.23 Technical Data Audit and Verification Cost

This is the cost of accomplishing certain system engineering tasks and of reviewing and auditing the technical data package. It is an element in any cost/benefit analysis.

3.8.24 Provisioning Data Cost

The cost of provisioning data is necessary in establishing a logistic support program. The cost could be duplicated if the system configuration changed due to a change in producers.

3.8.25 Support Equipment Cost

This includes the cost of ground handling equipment, general and special test equipment, installation and aligning tools, etc. These costs increase as the system configuration changes. They are a factor in considering an ECP or a second production source.

3.8.26 Transportation Cost

This is a cost to be considered when evaluting alternative support plans or relocating the manufacturing facility. Usually this cost factor is minor.

3.8.27 Logistic Management Cost

This is the cost of managing a logistic program. It includes the cost of new stock numbers, acquiring and maintaining usage data, personnel, computer, and report costs. These elements are important in source selection, logistic support concept evaluation, ECP reviews and cost/benefit analyses concerning second production sources.

3.8.28 Test Equipment Maintenance and Calibration Cost

This is a cost element used in evaluating system design and support concepts. It is important when considering ECPs or second production sources.

3.8.29 Staff/Command Training Cost

This cost element is initially funded by the program manager and later by the training command. It places a demand on the PMO's time. It is important to the program manager during operational testing and also important in acquiring user acceptance.

3.8.30 Technology Transfer Cost, Developer

This is the price paid to the developer for transferring technology. It may be the cost of a technical data package, royalties or incentives. It is an element in any cost/benefit analysis concerning the feasibility of a second source.

3.8.31 Technology Transfer Cost, Secound Source

This is the cost of educating a second producer to build the end item. It is a significant element in considering a second production source.

3.8.31 Non-Recurring Production Cost, Second Source

This is the cost of tooling, test equipment, methods, industrial engineering, inspection procedures, and purchase orders associated with establishing a production capability. This element is significant when considering the economies of a second source.

3.8.33 Learning Curve, Second Source

This represents the cost reduction expectation associated with the number of end items procured. It is an important element in considering production alternatves.

3.8.34 Educational Buy Qualification Cost

This is the cost of qualifying the end item produced by the second source.

3.8.35 Value of the Educational Buy

This is the value to the government of the educational buy end items after they have been qualified. It is an offset to the cost of technology transfer.

3.9 SYSTEM AND TECHNOLOGY FACTORS

3.9.1 Desired Performance Change

The degree of change in performance desired over existing systems directly affects the cost and time required to develop and test a new generation weapon system. A low-technology aircraft can be designed in a few years; a space shuttle may take ten to fifteen years from initiation to an operational system.

3.9.2 Required Level of Technology

The required level of technology to implement a weapon system affects the development cost, development time, required test resources, government facilities that may support the de-

TABLE 3.9-1
SYSTEM AND TECHNOLOGY FACTORS

Factor	Effect			
ϕ_0	ϕ_I	ϕ_{II}	ϕ_{III}	ϕ_{IIIB}
Desired Performance Change	1	1	1	
Required Level of Technology	1	1	1	
Change Rate of Technology	1	1	1	1
Physical Characteristics (Mass, Volume, etc)	1	4		
Software Dependency	1	1	1	
Magnitude of Software Effort	1	1	1	
Level of System Integration	1	1	1	
Operating Mode (Manual/ Automatic)	6	6		
Operational Concept	6	3		
Interface Requirements	1	3	1	
Operating Environment	3	6		
Maintenance Concept	3	6	3	
Reliability Requirements	3	3	1	
Supply Support Concept	3	6	1	
Availability Goals	3	3	1	
Personnel Requirements	3	6		
Training Requirements	3	6		
Proprietary Data		6	1	
Installation Data/Plans	3	1	1	
Functional Configuration		6		
Technical Risk Areas	1	1	1	

TABLE 3.9-1 (Continued)
SYSTEM AND TECHNOLOGY FACTORS

Factor	Effect				
.	ϕ_0	ϕ_I	ϕ_{II}	ϕ_{III}	ϕ_{IIIB}
Configuration Control Requirements			5	1	
Applicability of MIL-SPECS	6	6	6	6	
Performance Thresholds		1	3	1	
Production/Manufacturing Technology		1	1	1	
Must Buy List		1		1	
NATO/RSI	1	1	5	1	
Test Facility Requirements		1	1		
Critical Material Requirements		1	1	3	
GFE/GFM/GFI	2	2	2	2	2
Configuration Baseline			1	1	
First Article/Acceptance Test				1	1
Quality Control Requirements			4	1	1
Production Alternatives			1	1	1
Software Support Plans		1	1	1	1
Interim Support Plans			6	6	1
Technical Data Requirements			6	6	1
Provisioning Data Requirements			6	1	1
Management Information Data			6	2	1
Systems Effectiveness Assessment		1	1	4	
Energy Consumption Projections			3		

TABLE 3.9-1 (Continued)
SYSTEM AND TECHNOLOGY FACTORS

Factor	Effect				
	$\emptyset_0$	$\emptyset_I$	$\emptyset_{II}$	$\emptyset_{III}$	$\emptyset_{IIIB}$
Performance Growth Projection			1	1	
Technology Transfer Methods	1	1		1	1

velopment, and the number of industries that may have the requisite experience to participate.

3.9.3 Change Rate of Technology

The rate at which a technology base is changing affects not only the cost and time of development of a new system, but also the design of the system itself. Digital electronic systems that require four to five years to design will be obsolete before entering production and will be subject to numerous engineering change proposals. If the weapon system design does not recognize that technology will continue to change, the first production article will also be obsolete, and subsequent equipments will be increasingly difficult to support. A weapon system based on a volatile technology should be evolutionary in nature, and should include plans for progressive improvement with time. Of utmost importance is the understanding and acceptance by the user organizations and independent test agency that the system is not "complete" and will continue to change. The logistic support concept must recognize the evolutionary nature of the system and tailor the documentation and sparing concepts accordingly.

3.9.4 Physical Characteristics (Mass, Volume, Etc.)

The physical characteristics of the system give insight into the magnitude of the development effort, the number and complexity of interfaces, the consumption and disposition of power, etc. This insight can be directly related to technical risk and can influence the choice of a D&V Phase strategy. The uncertainties remaining at the end of the D&V Phase affect the scope of work to be accomplished during FSD.

3.9.5 Software Dependency

Technical risk is directly proportional to the degree of computer software dependency. During the development cycle, two degrees of freedom (and sources of errors) exist, hardware and software. Where parallel development is required, schedule and funding requirements must be adjusted to recognize this additional level of complexity.

3.9.6 Magnitude of Software Effort

When the software effort is large, the availability of quality system integrators and computer program designers becomes extremely important. During the D&V Phase, the technical risk would warrant the consideration of software simulation of the system being designed (wrap around simulation). If the software effort is both large and critical to the operation of the system, prototyping is a reasonable risk avoidance alternative.

3.9.7 Level of System Integration

A large weapon system with many complex internal and external interfaces is a high technical risk program; not necessarily because it embodies advanced technology, but because it

is vulnerable to a large number of error sources. The uncertainties associated with this type of development would suggest a prototyping effort during the D&V Phase if time and resources permit. If many uncertainties were carried over into Phase II, an incremental FSD would be indicated if the inventory objectives were large. A concurrent FSD/production strategy which included a planned performance improvement program may be warranted for small production quantities.

3.9.8 Operating Mode (Manual/Automatic)

The nature of the operational deficiency often dictates a requirement for an automatic system. This is usually the case when a large number of decisions must be made in a very short time. Automatic pilots, approach power compensators, high speed switching networks, etc. are illustrative. The trend in the last decade is toward digital computer controlled systems.

If an automatic system is to be designed, the program manager must make allowances for the additional scope of work and technical risk. Many other facets of the program plan must also reflect this design parameter; reliability, maintainability, and system support concepts are a function of the design complexity.

3.9.9 Operational Concept

Operational concept or tactical employment refers to how the new system will be used. The tactical doctrine, technical interfaces with other systems, and training plans must evolve in parallel. If the schedule allows, a system that differs significantly from the status quo can be a candidate for concurrent FSD and low rate production. This approach allows significant user participation during the test program and the initial deployment phase with feedback to the developing

agency. If the urgency of need does not allow a low production rate, development of tactical doctrine may lag deployments.

3.9.10 Interface Requirements

A system that must communicate with other systems is much more complex than self-contained systems. Missiles, sonobuoys, small engines, etc. have relatively few compatability requirements with an external environment. Command and control, communication, and fire control systems have many complex interface requirements. Configuration control is very important to complex systems.

A successful second source price competition is more likely with a low technology system with few interface requirements.

3.9.11 Operating Environment

The physical environment in which the system is to operate is directly related to the development and test time and the cost of these activities. Generally, system cost is reflected in the environmental specifications called out in the contract that controls the development. A high altitude aviation system may cost 15-20% more than a similar ground based system.

3.9.12 Maintenance Concept

The maintenance concept is established as the system design evolves. The actual configuration of the hardware determines if it can be supported through piece part replacement, module substitution and depot repair, or some intermediate concept. The effort expended on support concepts during the

development cycle flows down to personnel, training, documentation, and test equipment requirements for the deployed system.

Parallel FSD of competing systems will generate a complete second set of logistic considerations that must be recognized in budgeting and planning process.

3.9.13 Reliability Requirements

The developing agency establishes a contract MTBF or reliability goal after considering the various elements of availability. This goal must be consistent with the personnel and training plans, logistic delay times, and sparing levels.

An MTBF not demonstrated during the test program may delay the program even if the availability goal is met. The establishment of an MTBF goal is not trivial.

3.9.14 Supply Support Concept

The supply support concept chosen for a system is a major factor in the cost of ownership and operational availability. It must be selected based on the discrete MTBF of the system parts, the cost of training, documentation, and desired operational availability.

When two systems are developed in competition, funds must be programmed to implement the more expensive support concept.

If a second production source is established, it is necessary to ensure that the follow-on system is compatible with the developer's support concept.

3.9.15 Availability Goals

Current directives indicate operational availability goals are to be used in system design. This philosophy requires the program manager to separate out contractor and government responsibilities. The developer can be held responsible for MTBF and repairability. The government is responsible for the quality, quantity, and education of the maintenance personnel, the number and type of spares on site, the leadtime for spares not on site, the general purpose test equipment, and many other factors that collectively establish the operational availability of the system.

It is significant that many of these factors are outside the direct control of the program manager. It is necessary that the PMO staff coordinate with many other commands and organizations if the operational availability goal is to be met.

3.9.16 Personnel Requirements

One of the overall objectives of every new development is to reduce the number and pay grade of support personnel.

When systems are being developed in competition, it is necessary that qualified PMO staff be available to evaluate personnel projections and to ensure that appropriate programming action is taken to support the personnel needs regardless of the system chosen.

3.9.17 Training Requirements

Training requirements are closely related to maintenance concept, supply support concept, personnel projections, and the level and change rate of technology.

To properly inform, elicit support, and coordinate the efforts of the recruiting, personnel, logistic, and training commands requires a competent PMO staff. The advent of competition increases the liaison problems many times over.

3.9.18 Proprietary Data

Private research is the source of much new technology. If the government plans to transfer this technology to a second production source it must first obtain rights to this data.

Negotiating a price is often difficult, defining adequately the extent of the data is an even more difficult undertaking. These problems are often circumvented by using a leader/follower technique for subsequent production if economic factors are favorable.

3.9.19 Installation Data/Plans

Firm configuration data including weight, moment, center of gravity, power requirements, dry air and humidity factors, navigational/gyro reference information, etc. is required at least 30 months prior to the installation date to accommodate the required planning and budgeting. Where commercial organizations are to install the equipment, additional time is required to prepare, negotiate and award a contract.

Competition during FSD would complicate the installation planning process. Competition coupled with any degree of concurrency would be rare if the installation effort was any thing but trivial.

3.9.20 Functional Configuration

A functional configuration is a description of the

system short of a production baseline. All internal and external interfaces are defined. The internal functions are defined and in most cases implemented. The amount of uncertainty associated with the effort to translate the functional configuration into a production configuration baseline defines the scope of work and degree of risk associated with FSD.

A full prototype program probably has few uncertainties to be resolved in FSD -- a contract definition D&V Phase program has many.

3.9.21 Technical Risk Areas

The alternative selected for each phase of development is a result of the program manager's perception of technical risk. He must choose an appropriate management technique and acquisition strategy to minimize these risks consistent with other program constraints.

3.9.22 Configuration Control Requirements

The configuration control requirements become increasingly severe as a program progresses from concept exploration efforts to production. Any production concept, other than single source production by the developer, increases the need for even tighter configuration control. The most demanding configuration control problem involves parallel production by two prime contractors, each being supported by separate subcontractors or vendors. Every ECP must be staffed through both primes, their subcontractors (where appropriate), and the government.

Parallel production of a high technology, complex system is a near impossible task.

3.9.23 Applicability of MIL-Specs

Current policy encourages tailoring MIL-specs to the intended use of the system under development. This concept is readily implemented during the early phases of development; it is very difficult to tailor MIL-specs for FSD or production. The success of a tailoring effort is a function of PMO size and expertise, as well as the attitude of supporting and higher level staffs.

3.9.24 Performance Thresholds

System requirements are stated in terms of performance thresholds. A system with high risk DCP performance thresholds is an excellent candidate for competitive prototyping during the D&V Phase.

3.9.25 Production/Manufacturing Technology

For complex systems, manufacturing finesse is as important as the access to system technical data. Specifically, the unlimited rights to technical data is insufficient to guarantee a successful second production source. A leader/follower production technique has a better chance of success than second sourcing a system with significant integration requirements.

3.9.26 Must Buy List

Some parts or subsystems must be acquired from a subcontractor or vendor because of proprietary data or manufacturing skills. If a second production source is considered, it is necessary to ensure that the critical subcontractors will support the new producer. If the developer controls certain critical subsystems, second sourcing may not be possible.

3.9.27 NATO/RSI

These considerations are operable during phase one. If a "U.S. only" solution to the problem is selected for development, NATO standardization acts as a program design constraint. Possible NATO and third-world sales may be considered in projecting total inventory requirements.

Should a joint NATO/US development be established, the combined funding availability will act as a program constraint. Further, the NATO partners may establish requirements and procedures that influence development alternatives.

3.9.28 Test Facility Requirements

If limited test facilities are not available when needed, entering production based only on ground based and or factory testing may be justified. The program manager must weigh the detrimental effects of a long break between FSD and production against the probable ECPs arising from a test program initiated after a production start.

3.9.29 Critical Material Requirements

The ability of a potential second production source to obtain critical materials (at a competitive price) may be the determining factor in establishing a price competition. Usually the developer has expended considerable effort and time establishing a source of materials. In some cases the developer may have been forced to make the critical parts himself because an outside source was not available. If so, the developer would not support a competitor until all hope of getting the contract himself had vanished.

3.9.30 GFE/GFM/GFI

The availability of required government resources can pace a development and production program and be the dominant factor in establishing a program schedule.

3.9.31 Configuration Baseline

The configuration baseline is a detailed description of a system ready to enter production. The number (and rate) of engineering change orders will give an insight into a schedule for obtaining a stable technical data package.

3.9.32 First Article/Acceptance Test

The completion of first article tests usually marks the time that a contractor can begin compiling a technical data package. The technical data package is the usual instrument of technology transfer for a second production source.

3.9.33 Quality Control Requirements

The quality control requirements of a program must be transferred to a second source if this production technique is considered. Quality control is a function not only of the contractor but also the number and experience of the DCAS inspectors that can be assigned.

3.9.34 Production Alternatives

In addition to the choice of a production contractor; the type contract, the quantity, the production rate, and the way risk is shared between the contractor and the government all effect the outcome of the program. As these factors are varied, the desirability of production alternatives may also vary.

3.9.35 Software Support Plans

If a second source is contemplated, the program manager must ensure that the follow-on product is compatible with the system software support plans. This can be a significant factor if hardware/software ECPs are anticipated.

3.9.36 Interim Support Plans

The interim support plan usually involves considerable initial production contractor participation. It is not prudent to attempt to establish a second source until the government assumes all support roles.

3.9.37 Technical Data Requirements

The technical data package is expensive. It is of value only when the system design is relatively stable, the government foresees a continuing requirement for the end item, the government intends to establish a second source, and the government has the technical resources to review and validate the data.

3.9.38 Provisioning Data Requirements

This data is required well in advance of the government assuming the logistic responsibilities. For the data to be meaningful, the system must be relatively stable, have reliability predictions for all logistically supportable parts and subsystems, and have some usage history. Often this dictates interim support directly from the producer for three to four years after the award of a production contract.

3.9.39 Management Information Data

The government requires a production contractor to have a cost/schedule tracking system that meets the criteria of DODD 7000.2 A second source will have to meet the same criteria as the initial producer. Qualification under the Cost/Schedule Control System Criteria (C/SCSC) takes time and could delay a production contract.

3.9.40 System Effectiveness Assessment

The program manager and an independent test agency must make an assessment of the system's effectiveness prior to the DSARC III review. This assessment, if unfavorable, can delay the production award and require the production plan to be restructured. A delay would likely require reprogramming of R&D funds for further engineering efforts.

An alternative to delaying production would be to structure a post-production, planned-improvement program.

3.9.41 Energy Consumption Projections

The program manager must make a projection of the energy consumption of the developed system prior to the DSARC III review. Second source or parallel production firms must meet the standard or be more efficient than the initial producer.

3.9.42 Performance Growth Projection

A post-production performance improvement program is, by its nature, a relatively unstable program with respect to the system configuration. This would tend to keep the program sole source and the contractor involved in interim support efforts.

3.9.43 Technology Transfer Methods

If an acceptable technical data package can be obtained and verified in time to establish a second source, this approach may be used as technology transfer. Otherwise the developer must participate in the technology transfer through a government incentivised effort such as a leader/follower program.

4. MEASURABLE RELATIONSHIPS

As the acquisition strategy alternatives became definitized, the influencing factors delineated, and the relationships among them examined, it became increasingly apparent that functional relationships exist which would provide insight into the results of pursuing a particular strategy, considering the combined impact of the relevant influencing factors. Since uncertainty is associated with many of the factors, the predicted result from pursuing a strategy alternative also has uncertainties. The most logical way of incorporating these uncertainties is with probability distributions. Thus, the approach taken is to assess the probability distributions resulting from pursuing a strategy alternative, given probability distributions of relevant factors.

As discussed in the preceding chapters, the result of pursuing a strategy alternative has many facets, each of potential significance to a particular situation. Any attempt at a complete enumeration would produce a list too large to be useful. Consequently, TASC proposes the following list of key questions. When answered in decision-oriented terms, they provide insight into the results expected from each strategy alternative and allow a decision-maker to select the strategy most appropriate for his situation:

- How much time will it take?
- How much will it cost?
- How successful will it be at reducing technical risk to an acceptable level?

- How much project management office support is required?
- How much flexibility does it have to accommodate unforseen events?
- How compatible is it with special considerations?

This list of key questions and the resulting relationships developed are considered preliminary and may be subject to change; yet they comprise a consistent set suitable for demonstrating feasibility and preliminary model development.

It should be emphasized that the methodology developed in this chapter provides relationships which are representative of the type of information a program manager should have available when contemplating acquisition strategy alternatives. It is therefore somewhat general in nature. Since each weapon system acquisition program invariably has special considerations which distinguish it from all others, the significance of individual attributes will vary from program to program. The methodology for incorporating this uniqueness aspect is presented in Chapter 6.

Throughout the remainder of this chapter, an acquisition strategy is considered to consist of a set of strategy alternatives, one for each of the remaining phases. Thus, at each milestone, acquisition strategy notation is as follows:

At Milestone	Acquisition Strategy Notation
0	$(A_i^0, A_j^1, A_k^2, A_\ell^3)$
I	(A_j^1, A_k^2, A_ℓ^3)

At Milestone	Acquisition Strategy Notation
II	(A_k^2, A_ℓ^3)
III	(A_ℓ^3)

where A_n^m denotes strategy alternative n for phase m.

4.1 TIME AND COST

During the initial phases of the investigation into appropriate quantifiable attributes, time-related attributes and cost-related attributes were considered separately. As the investigation progressed it became apparent that they must be considered together. Accordingly, the principal quantifiable attributes addressing the issues of time and cost for a given acquisition strategy are:

- The probability distribution of the time to initial operational capability (IOC)
- The probability distribution of total cost
- The probability distribution that the cost for each of the next three fiscal years does not exceed the funds programmed for those years.

In order to calculate these probability distribution functions, it is assumed that the following probability density functions can be ascertained by combining historical information with subjective assessments:

- $f_L^{nm}(x)$ -- the probability density function of the lead-time required to complete the contracting actions necessary to execute alternative m in phase n (n=0,1,2,3)
- $f_M^{n}(x)$ -- the probability density function of the lead-time required for milestone n (n=1,2,3)
- $f_B^{s}(x)$ -- the probability density function of the amount of funds available in the fiscal year budget for year s (s=1,2,3) (i.e., each of the next three years)
- $f_{C,E}^{nm}(x,y)$ -- the joint probability density function of the cost and time associated with the execution of strategy alternative m in phase n (n=0,1,2,3). This may also be a function of weapon system type and the perceived change in technology level.

For n=3, the production phase, a preferred approach for deriving $f_{C,E}^{nm}(x,y)$ is from a generalized form of the TASC model for evaluating the effects of competition during production. The current TASC model is described in Appendix A. Data supporting the model assumptions are presented in Appendix B. A description of how the model can be generalized and applied to all alternatives for phase 3 is contained in Appendix C.

From the four basic probability density functions, the following are determined:

$$f_E^{nm}(x) = \int_{-\infty}^{\infty} f_{C,E}^{nm}(y,x)dy \tag{4.1-1}$$

$$f_C^{nm}(x) = \int_{-\infty}^{\infty} f_{C,E}^{nm}(x,y)dy \tag{4.1-2}$$

where $f_E^{nm}(x)$ is the probability density function of the time required to <u>execute</u> acquisition strategy alternative m in phase n (n=0,1,2,3) and $f_C^{nm}(x)$ is the probability density function of the <u>cost</u> of pursuing strategy alternative m in phase n.

For strategy analysis performed in preparation for Milestone III, the time and cost related atttributes for acquisition strategy (A_ℓ^3) are derived as follows:

- $F_T^\ell(z) \equiv$ the probability distribution of the time to IOC

$$F_T^\ell(z) = \int_0^z f_L^{3\ell}(x)\ f_E^{3\ell}(z-x)dx \qquad (4.1\text{-}3)$$

- $F_C^\ell(z) \equiv$ the probability distribution of total remaining cost

$$F_C^\ell(z) = \int_0^z f_C^{3\ell}(x)dx \qquad (4.1\text{-}4)$$

- $G_s^\ell(z) \equiv$ probability distribution that the cost of the strategy during fiscal year s does not exceed the funds programmed for fiscal year s (s=1,2,3)

$$G_s^\ell(z) = \int_{-\infty}^z h_s^\ell(x) f_B^s(x-z)dx \qquad (4.1\text{-}5)$$

- $h_s^\ell(x) \equiv$ probability density of the cost of the strategy during year s

$$h_s^\ell(x) = \frac{\int_{s-1}^s f_{C,E}^{3\ell}(x,y)dy}{\int_{s-1}^s f_C^{3\ell}(y)dy} \qquad (4.1\text{-}6)$$

It should be noted that the formulation for $G_s^\ell(x)$ assumes that once production is successfully initiated it continues as planned without interruptions.

For strategy analysis performed in preparation for Milestone II, the time and cost attributes for acquisition strategy (A_k^2, A_ℓ^3) are derived as follows:

- $F_T^{k\ell}(z) \equiv$ probability distribution of the time to IOC

$$F_T^{k\ell}(z) = \int_0^z \int_0^{z-x} \int_0^{z-x_1-x_2} \int_0^{z-x_1-x_2-x_3} f_L^{2k}(x_1) f_E^{2k}(x_2) f_M^3(x_3) f_L^{3\ell}(x_4) f_E^{3\ell}(z-x_1-x_2-x_3-x_4) dx_1 dx_2 dx_3 dx_4 \quad (4.1\text{-}7)$$

- $F_C^{k\ell}(z) \equiv$ probability distribution of total remaining cost

$$F_C^{k\ell}(z) = \int_0^z f_C^{2k}(x)\ f_C^{3\ell}(z-x)dx \quad (4.1\text{-}8)$$

- $G_s^k(z) \equiv$ probability distribution that the cost of the strategy during fiscal year s does not exceed the funds programmed for fiscal year s (s=1,2,3)

$$G_s^k(z) = \int_{-\infty}^z h_s^k(x)\ f_B^s(x-z)dx \quad (4.1\text{-}9)$$

$$h_s^k(x) = \frac{\int_{s-1}^s w_{C,E}^{k\ell}(x,y)dy}{\int_{s-1}^s w_C^{k\ell}(x)dx} \quad (4.1\text{-}10)$$

$$w_{C,E}^{k\ell}(x,y) = \frac{d^2 W_{C,E}^{k\ell}(x,y)}{dxdy} \quad (4.1\text{-}11)$$

$$W_{C,E}^{k\ell}(x,y) = \int \cdots \int_D f_{C,E}^{2k}(x_1,y_1) f_m^3(y_2) f_L^{3\ell}(y_3) f_{C,E}^{3\ell}(x_2,y_4) dx_1 dx_2 dy_1 \ldots dy_4 \quad (4.1\text{-}12)$$

where

$$D = \{(x_1,y_1),y_2,y_3,(x_2,y_4): \; x_1+x_2 \le x \text{ and } y_1+y_2+y_3+y_4 \le y\}$$

$$w_C^{k\ell}(x) = \int_{-\infty}^{\infty} w_{C,E}^{k\ell}(x,y)dy \quad (4.1\text{-}13)$$

For acquisition strategy analysis performed in preparation for Milestone I, the time and cost attributes for strategy (A_j^1, A_k^2, A_ℓ^3) are as follows:

- $F_T^{jk\ell}(z) \equiv$ probability distribution of the time to IOC

$$F_T^{jk\ell}(z) = \int \cdots \int_D f_L^{1j}(x_1) f_E^{1j}(x_2) f_M^2(x_3) f_L^{2k}(x_4) f_E^{2k}(x_5) f_M^3(x_6) f_L^{3\ell}(x_7) f_E^{3\ell}(x_8) dx_1 \ldots dx_8 \quad (4.1\text{-}14)$$

where

$$D = \{(x_1, \ldots, x_8): \sum_{i=1}^{8} x_i \le z\}$$

- $F_C^{jk\ell}(z) \equiv$ probability distribution of the total remaining cost

$$F_C^{jk\ell}(z) = \int_0^z \int_0^{z-x_1} f_c^{1j}(x_1) f_c^{2k}(x_2) f_c^{3\ell}(z-x_1-x_2) dx_1 dx_2 \quad (4.1\text{-}15)$$

- $G_s^j(z) \equiv$ probability distribution that the cost of the strategy during fiscal year s does not exceed the funds programmed for fiscal year s (s=1,2,3)

$$G_s^j(z) = \int_{-\infty}^{z} h_s^j(x) f_B^s(x-z)dx \tag{4.1-16}$$

$$h_s^j(x) = \frac{\int_{s-1}^{s} w_{C,E}^{jk\ell}(x,y)dy}{\int_{s-1}^{s} w_C^{jk\ell}(x)dx} \tag{4.1-17}$$

$$w_{C,E}^{jk\ell}(x,y) = \frac{d^2 W_{C,E}^{jk\ell}(x,y)}{dxdy} \tag{4.1-18}$$

$$W_{C,E}^{jk\ell}(x,y) = \int \cdots \int_D f_{C,E}^{1j}(x_1,y_1) f_m^2(y_2) f_L^{2k}(y_2) f_{C,E}^{2k}(x_2,y_4) f_m^3(y_5) f_L^{3\ell}(y_6) f_{C,E}^{3\ell}(x_3,y_7) dx_1 dx_2 dx_3 dy_1 \ldots dy_7 \tag{4.1-19}$$

where

$$D = \{(x_1,y_1),y_2,y_3,(x_2,y_4),y_5,y_6,(x_3,y_7): \sum_{i=1}^{3} x_i \le x \text{ and } \sum_{i=1}^{7} y_i \le y\}$$

$$w_C^{jk\ell}(x) = \int_{-\infty}^{\infty} w_{C,E}^{jk\ell}(x,y)dy \tag{4.1-20}$$

For strategy analysis performed in preparation for Milestone 0, the time and cost attributes for acquisition strategy $(A_i^0,A_j^1,A_k^2,A_\ell^3)$ are:

- $F_T^{ijk\ell}(z) \equiv$ probability distribution of the time to IOC

$$F_T^{ijk\ell}(z) = \int_D \cdots \int f_L^{oi}(x_1) f_E^{oi}(x_2) f_M^1(x_3) f_L^{1j}(x_4) f_E^{1j}(x_5) f_M^2(x_6)$$
$$f_L^{2k}(x_7) f_E^{2k}(x_8) f_M^3(x_9) f_L^{3\ell}(x_{10}) f_E^{3\ell}(x_{11})\ dx_1 \ldots dx_{11} \tag{4.1-21}$$

where

$$D = \{(x_1, \ldots, x_{11}): \sum_{i=}^{11} x_i \leq z\}$$

- $F_C^{ijk\ell}(z) \equiv$ probability distribution of total cost

$$F_C^{ijk\ell}(z) = \int_0^z \int_0^{z-x_1} \int_0^{z-x_1-x_2} f_c^{0i}(x_1) f_c^{1j}(x_2) f_c^{2k}(x_3)$$
$$f_c^{3\ell}(z-x_1-x_2-x_3) dx_1 dx_2 dx_3 \tag{4.1-22}$$

- $G_s^i(z) \equiv$ probability distribution that the cost of the strategy during fiscal year s does not exceed the funds programmed for fiscal year s (s=1,2,3)

$$G_s^i(z) = \int_{-\infty}^{z} h_s^i(x) f_B^s(x-z) dx \tag{4.1-23}$$

$$h_s^i(x) = \frac{\int_{s-1}^{s} w_{C,E}^{ijk\ell}(x,y) dy}{\int_{s-1}^{s} w_C^{ijk\ell}(x) dx} \tag{4.1-24}$$

$$w_{C,E}^{ijk\ell}(x,y) = \frac{d^2 W_{C,E}^{ijk\ell}(x,y)}{dxdy} \tag{4.1-25}$$

$$W^{ijk\ell}_{C,E}(x,y) = \int_D \cdots \int f^{0i}_{C,E}(x_1,y_1) f^1_m(y_2) f^{1j}_L(y_3) f^{1j}_{C,E}(x_2,y_4)$$
$$f^2_m(y_5) f^{2k}_L(y_6) f^{2k}_{C,E}(x_3,x_7) f^3_m(y_8) f^{3\ell}_L(y_9) f^{3\ell}_{C,E}(x_4,y_{10})$$
$$dx_1 \ldots dx_4 \; dy_1 \ldots dy_{10} \qquad (4.1\text{-}26)$$

where

$$D = \{(x_1,y_1),y_2,y_3,(x_2,y_4),y_5,y_6,(x_3,y_7),y_8,y_9(x_4,y_{10}): \sum_{i=1}^{4} x_i \leq x \text{ and } \sum_{i=1}^{10} y_i \leq y\}$$

Depending on the form of the individual probability density functions in the above equations, many of the multiple integrals may have to be evaluated numerically. However, since a reasonable estimate of the resulting probability distributions is adequate for comparing strategy alternatives, a somewhat "granular" type of numerical integration routine can be effected. This methodology would provide results of sufficient accuracy while maintaining computer efficiency.

4.2 TECHNICAL RISK

In order to quantify the degree to which a proposed acquisition strategy would reduce the technical risk or uncertainty associated with a weapon system concept, one must first quantify the perceived uncertainty. Several approaches are available. Perry* developed a numerical scale ranging from zero to 20 which categorized various levels of technical advances, and rated a number of systems from the 1950s and 1960s on the scale (Fig. 4.2-1). An alternate approach, recommended by

*Perry, R., Smith, G.K.,, Harman, A.J., and Henrichsen, S., "System Acquisition Strategies," Rand, Santa Monica, CA, (R-733-PR/ARPA), June 1971.

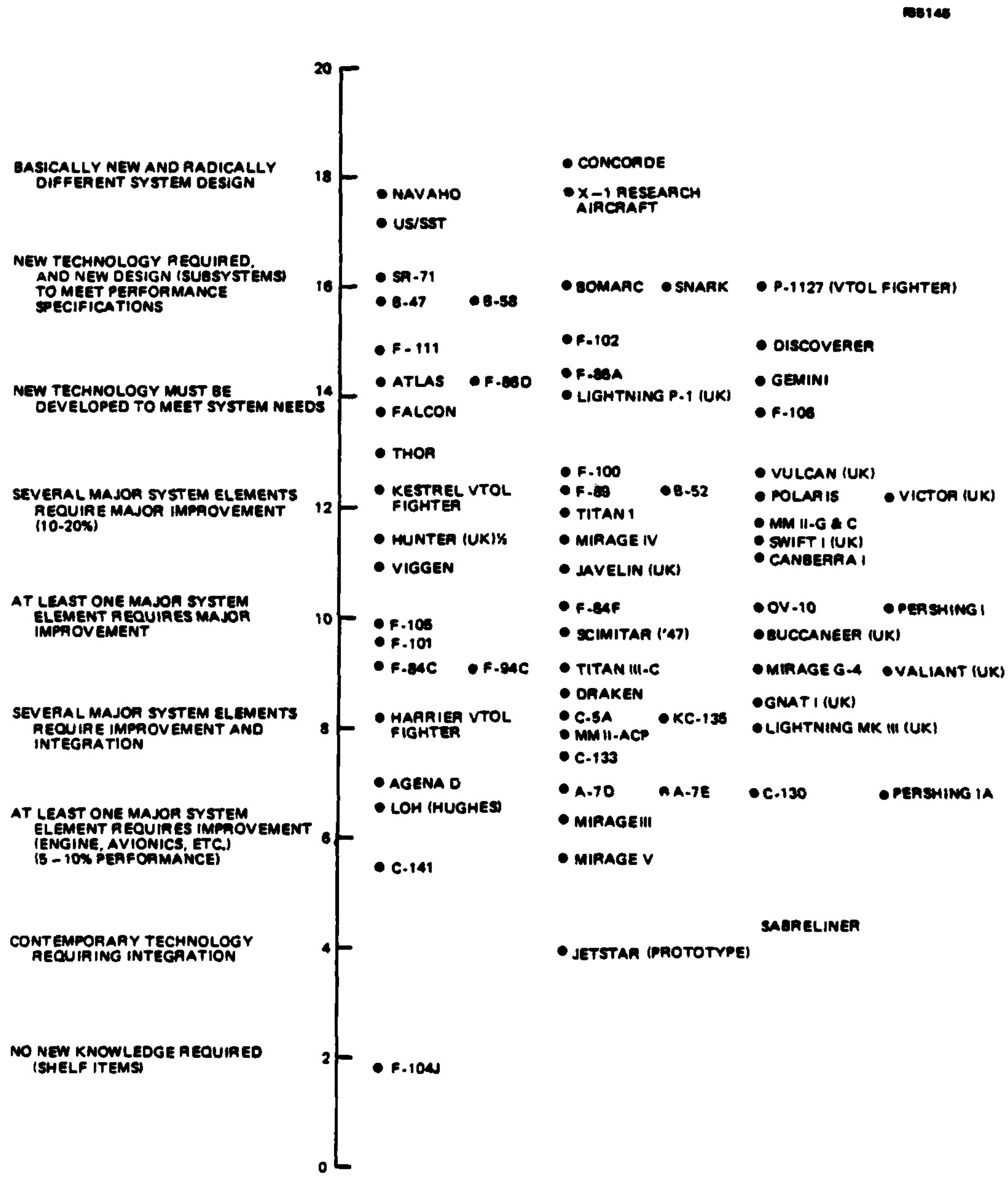

Figure 4.2-1 Technical Advance Ratings by Perry, et al.

TASC, is to separate the various aspects of technical risk into three principal components:

- the level of technological advance (hardware)
- the degree of system integration required
- the level of software dependency and the magnitude of the software effort.

These components were selected because the acquisition strategy alternatives address each component in a different manner. A numerical categorization for each component can then be developed perhaps in a manner similar to that used by Perry. Once this is accomplished the perceived technical risk associated with a weapon system concept would be quantified by a set of three numbers (r_1, r_2, r_3), each addressing one of the principal components.

By obtaining subjective assessments from a group of knowledgeable individuals, a reliable measure could be obtained of the effect strategy alternatives in phases one and two have on each component of technical risk. Thus, the perceived level of technical risk, quantified as (r_1, r_2, r_3), is modified by the phase one strategy alternative to become (r_1', r_2', r_3'), which is further modified by the phase two strategy alternative to become (r_1^*, r_2^*, r_3^*), which represents the expected level of technical risk remaining at the beginning of the production phase given one pursues those strategy alternatives. This is depicted in Fig. 4.2-2.

To evaluate the degree of acceptability of the levels of technical risk resulting from pursuing a particular combination of strategy alternatives, a feasible approach is to calculate an acceptability index (AI) for each set of alternatives as follows:

$$AI(r_1^*, r_2^*, r_3^*) = \alpha_1 r_1^* + \alpha_2 r_2^* + \alpha_3 r_3^* \tag{4.2-1}$$

for suitably chosen parameters α_i. Should the straightforward summation prove inadequate, a more generalized form would be as follows:

$$AI(r_1^*, r_2^*, r_3^*) = \sum_{i=1}^{3} \alpha_i r_i^* + \sum_{i=1}^{3} \sum_{j>i} \alpha_{ij} r_i^* r_j^* + \alpha_{123} r_1^*, r_2^*, r_3^* \tag{4.2-2}$$

for suitably chosen parameters α_i, α_{ij} and α_{123}.

With either approach, the result would associate with each feasible set of strategy alternatives a measure as to how successful it would be at reducing perceived technical risk.

(r_1, r_2, r_3) → [Phase I Strategy Alternative] → (r_1', r_2', r_3') → [Phase II Strategy Alternative] → (r_1^*, r_2^*, r_3^*)

Perceived Levels of Technical Risk

Expected Levels of Technical Risk Remaining at Beginning of Production Phase

Figure 4.2-2 Technical Risk Reduction

4.3 PROJECT MANAGEMENT OFFICE (PMO) SUPPORT

The size of a program office staff affects the degree of participation the office has with industry, as well as the quality of the participation. A small office can theoretically pursue any strategy alternative; however, the potential for success can vary considerably. All offices must devote a certain amount of time and effort to internal tasks (budgeting,

contracting, etc.), and to handling the daily crises which inevitably arise. The time remaining is devoted first to directing, monitoring, evaluating, and educating contractors, and then to data generation and retention. The time needed to successfully manage varies considerably among the strategy alternatives.

Given these considerations, the only realistic quantifiable attribute related to PMO support would consist of the development of a measure of potential success for each strategy alternative as a function of PMO size (i.e., a measure relating how well a PMO of a given size could successfully manage each strategy alternative). This could be accomplished by combining the subjective assessments from a group of experienced individuals. Such a measure should not be considered as a perfect indicator of success, and it would surely vary with the quality of the PMO staff as well as the quantity; however such a measure would be useful for comparative analysis and would provide insight to the decision-making process.

Given such a measure for each strategy alternative, the logical choice for combining these into a single measure for the acquisition strategy would be to use the minimum value of the measure of the individual alternatives. Expressed mathematically,

$$v(A_i^0,A_j^1,A_k^2,A_\ell^3) = \mathrm{Min}[v(A_i^0),v(A_j^1),v(A_k^2),v(A_\ell^3) \qquad (4.3\text{-}1)$$

where

$v(A_i^0,A_j^1,A_k^2,A_\ell^3)$ = the measure of potential success for acquisition strategy $(A_i^0,A_j^1,A_k^2,A_\ell^3)$

$v(A_m^n)$ = the measure of potential success for strategy alternative m in phase n.

4.4 FLEXIBILITY

Once an acquisition strategy is selected, action is taken to execute the initial phase of the strategy, and planning and programming are performed for the subsequent phases; all under the assumption that the selected strategy will proceed as designed. Occasionally (perhaps even frequently), situations arise, such as budget reductions and schedule delays, which necessitate either a revision to the selected strategy or, at times, even a shift to an entirely different strategy. Flexibility, as used in this context, refers to the ease with which this can be effected.

With acquisition strategy defined in terms of strategy alternatives over four development phases, one way to depict this formulation is in a decision tree (Fig. 4.4-1). As such, at each milestone, a decision is made to proceed along one branch of the tree. As this occurs, a large number of possible

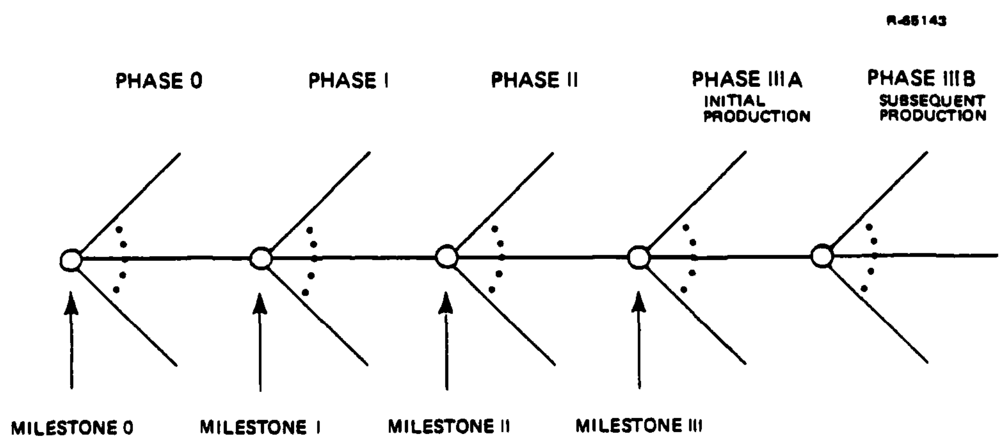

Figure 4.4-1 Acquisition Strategy Depicted as a Decision Tree

paths through the tree are eliminated from further consideration. Thus, a straightforward measure of the degree of flexibility associated with an acquisition strategy is the number of remaining feasible paths through the decision tree once execution of the strategy has been initiated.

Accordingly, the flexibility factor (FF) for an acquisition strategy is defined as follows:

- For strategy analysis performed at Milestone 0,

  $FF(A_i^0, A_j^1, A_k^2, A_\ell^3) = (\beta_1, \beta_2, \beta_3, \beta_4)$

- For strategy analysis performed at Milestone I

  $FF(A_j^1, A_k^2, A_\ell^3) = (\beta_2, \beta_3, \beta_4)$

- For strategy analysis performed at Milestone II

  $FF(A_k^2, A_\ell^3) = (\beta_3, \beta_4)$

- For strategy analysis performed at Milestone III

  $FF(A_\ell^3) = (\beta_4)$

where

β_1 = the number of remaining feasible paths through the decision tree once execution of the phase 0 strategy alternative is initiated

β_2 = the number of remaining feasible paths through the decision tree once execution of the phase I strategy alternative is initiated

β_3 = the number of remaining feasible paths through the decision tree once execution of the phase II strategy alternative is initiated

β_4 = the number of remaining feasible alternatives for subsequent production once initial production is initiated.

4.5 SPECIAL CONSIDERATIONS

For each weapon system acquisition program, there are invariably a number of special considerations unique to that program and may involve considerations such as the nature of the specific program, particular contractors involved, specific individuals in decision-making positions at the time, and the particular interests of individuals in DoD and the Congress. If these aspects are to be included in an acquisition model, it will have to be performed on an individual basis working together with the program office. A few factors, however, can be included in a general model.

The presence or absence of competition is a consideration which can be included. For a given acquisition strategy, each phase can readily be placed into one of the following three categories:

- it maintains competition
- it is a single source resulting from competition in the previous phase
- it is sole source (the absence of competition).

Thus, each acquisition strategy can be characterized by a vector $\gamma=(\gamma_i)$, where each γ_i indicates one of the above categories for each phase in the strategy.

Mobilization is a consideration which may lend itself to a similar development. By considering such aspects as the location of the contractors, their production capacities together with the variance in cost associated with different production rates, and the availability of critical subcontractors, an indicator may be developed which assesses the degree to which a particular strategy alternative supports mobilization interests. The methodology has not been developed, but the approach appears feasible.

5. DATA AVAILABILITY

In order to determine if data can be obtained in sufficient quantity and quality to support the development of an historical data base, the following four major weapon system acquisition programs were examined in detail:

- (U.S. Army) YAH-64 Advanced Attack Helicopter
- (U.S. Navy) AN/SLQ-32 Shipboard Electronic Warfare System
- (U.S. Air Force) E-3A Airborne Warning and Control System
- (Joint Program) ALQ-165 Airborne Self-Protection Jammer.

The following sections provide a synopsis of each program and discuss the issue of data availability.

5.1 (U.S. ARMY) YAH-64 ADVANCED ATTACK HELICOPTER

5.1.1 Program Synopsis

The Advanced Attack Helicopter (AAH) Program office is a multilevel organization responsible for: the AAH development and acquisition; Target Acquisition Designation System/ Pilot Night Vision System (TADS/PNVS) development and acquisition; and the development and type classification of the 30 mm ammunition for the installed 30 mm gun. The AAH program manager directs the efforts of the TADS/PNVS project manager, the 30 mm

product manager and seven divisions/offices within the program organization. In addition to the program management division, configuration management office, technical management division, product assurance office, logistic management division, procurement and production division and operations research division, the AAH program manager directs the assistant project managers for test and evaluation, requirements and logistics.

The AAH program evolved from efforts in 1971 and 1972 to explore the possibility of upgrading existing helicopters to meet the Army's stated operational requirements. Parallel contracts were awarded to the major companies in the helicopter industry. The results of these studies and tests led to the conclusion that a new attack helicopter system should be developed.

In September of 1972, the U.S. Army approved a new helicopter development program; the DEPSECDEF authorized the release of the AAH RFP in November of that year. The original RFP specified a $1.6M recurring fly-away cost in FY-72 dollars. Subsequent DoD policy revised the design-to-cost goal to include nonrecurring costs.

The development plan, as approved in the 1972 DSARC review, called for competitive prototypes to be built during the Demonstration and Validation Phase, and a single winning design to enter Full-Scale Development (FSD).

In July 1973, Bell Helicopter Company and Hughes Helicopters were awarded contracts to design and fabricate a static test article, a ground test vehicle, and two flying prototypes.

The first flight was in September of 1975. One year later, the Secretary of the Army selected the Hughes YAH-64 as

the system to enter FSD. The DSARC review authorizing FSD was held in December 1976.

The Phase II (FSD) program is scheduled for 56 months. Hughes will modify the two development prototypes to reflect the changes desired by the government, and build three additional prototypes. The development of the HELLFIRE, 30 mm cannon and 2.75 rocket subsystems will also be completed during FSD. OSD directed that the TADS/PNVS be developed as a competitive project. Contracts were awarded to Martin Marietta and Northrop Corporation in March of 1977.

Congressional budget actions delayed the work on additional prototypes until FY-78 and extended the FSD schedule.

The AAH program has been restructured and the schedule revised because of guidance from OSD and R&D funding shortfalls. The inventory objectives have remained constant. The production plan is not firm, but if the FSD keeps to its current schedule, the first production delivery should occur in November of 1983, and the last delivery is expected in March of 1990.

The AAH program can be characterized as follows:

- Competitive Contract Definition
- Competitive Prototypes during the demonstration phase
- Single source FSD
- Competitive subsystem prototypes
- Single source FSD for subsystems
- Single source production
- GFE engines

- R&D shortfalls during development
- Schedule stretch out
- Descoping development efforts.

5.1.2 Data Assessment

Data sources and quality vary. The program development history prior to November 1972 is vague. Actual program events since 1972 are well documented.

Actual program funding since 1972 is well documented; initial estimates are not available. The early FYDP requirements could not be broken out to identify the Army's initial budget planning. Further, the initial planning associated with program support, laboratory efforts, program management office, contractor studies, etc., were not recovered. The actual expenditures were generally available but located in different files. The overall quality and availability of this information was considered good to excellent.

The documentation of major events was readily available. Contract awards, major decisions, and reviews are reflected in the DCP and the SAR. Some major schedule planning was reflected in the DCP; most lower level planning was not recovered. Actual event data are excellent; major event planning information was good. Other planning schedule data were poor.

The inventory objective has remained essentially fixed throughout the program.

Major changes in performance requirements were well documented since 1972. Prior requirement data was not recovered.

The general acquisition strategy for the AAH was established in 1972. It called for competitive prototypes during the D&V phase, a design-to-cost goal against a fixed inventory objective, a fly-off to determine the single source FSD contractor and a single source production. The Army required the AAH to use the T-700 engine by General Electric. In December of 1976, OSD required the TADS/PNVS to be a competitive project. Production rates, yearly requirements, and contract type were not firm as of April 1980.

Data were recovered from SARs, DCP, contract files, published fact sheets, interviews with contracting officers, members of the project office, the Washington Field Office, and various members of the USADARCOM staff.

5.2 (U.S. NAVY) AN/SLQ-32 SHIPBOARD ELECTRONIC WARFARE SYSTEM

5.2.1 Program Synopsis

The AN/SLQ-32 project office is a branch within the Reconnaissance, Electronic Warfare, Special Operations and Naval Intelligence (REWSON) program office (PME 107) of the Naval Electronic Systems Command. The PMO is responsible for the development, acquisition, and logistic support of a modular family of shipboard electronic warfare systems. The project manager directs a small office (average ten people) and draws software support from the Naval Surface Weapons Center, Dahlgren, Virginia.

The SLQ-32 program began in October 1971 when the Chief of Naval Operations established a program to design, prototype, test, and procure a coherent series of electronic

warfare systems for near fleet-wide installation. This new start was prompted by the recognization that the expected production cost of EW systems under development would preclude their installation in all but capital ships.

A modular family of equipment was directed from which suitable configurations for a wide range of ships could be obtained at an affordable cost. The requirement document, dated 23 May 1972, defined four cost levels ranging from $.5M to $3M. It implied that additional costs should provide enhanced performance but levied no specific technical or operational requirements. The requirements document was further amplified in verbal briefings by the ANS(R&D)/Systems: the guidance was the forerunner of OMB Circular A-109 and DoDD 5000.28.

In July of 1972, the new project was synopsized in the Commerce Business Daily. The response was greater than expected; over forty companies expressed the desire to participate.

A RFP was issued in August to accomplish a contract definition (CD) effort delineating the cost, schedule and performance to be achieved during FSD. Six parallel fixed price contracts were awarded in January of 1973. Cutler Hammer Co. AIL Division, Hughes Aircraft Co., Raytheon Co. ESD, RCA, Sanders Assoc., and Westinghouse provided their proposals for FSD in May 1973. The Naval Material Command briefed the Vice Chief of Naval Operations and subsequently, the CNO Executive Board in June. The object of that briefing was to provide an industry view of what technical capabilities could be achieved for a specified price.

The CNO descoped the program. The four performance/cost levels were reduced to three; the new prices the Navy was willing to pay were redefined as $.3M, $.5M, and $1.4M. The inventory objective was changed to reflect three suites.

The source selection authority decided that three companies were outside the competitive range. The remaining companies were requested to revise their FSD proposals to reflect the new Navy guidance.

Competitive FSD began in October 1973 with the award of contracts to Hughes Aircraft and Raytheon Company to build a land-based test system and one for testing at sea.

The FSD extended about six months over the original schedule. Both contractors experienced a cost growth of 38% over the 1973 estimates. (This was less than the compound inflation rate). The inability of the Navy to provide R&D funds to offset inflation caused further descoping of the FSD statement of work.

Following a test program in 1976, the Chief of Naval Material selected Raytheon Company to be the production company.

This decision was implemented in a four year - multi-year fixed price incentive contract with economic price adjustment provisions to accommodate abnormal inflation. This contract represented about 80% of the Navy's expected requirements as seen in 1976. It was signed in May 1977.

The SLQ-32 program can be characterized as follows:

- Competitive contract definition
- Competitive FSD

- Single source production
- 4 Year MYC/FFI with EPA
- R&D shortfalls during development
- Schedule stretch out in development
- Descoping development efforts
- Continuing test program after production began
- Contractor initial logistic support
- Very short program.

5.2.2 Data Assessment

Data sources and quality are considered good to excellent. The program had one manager from its inception to the third year of production. The lead engineer is still with the program. The contracting office has been with the program since early in the FSD effort.

Program history and acquisition strategy are available. The original acquisition strategy was documented in an advanced procurement plan (APP) in 1972. It changed little over the course of the program.

The actual funds expended is well documented. This includes the resources allocated to prime contractors, laboratories, contractor support, test programs, and rented facilities. Initial planning is not generally available. Budget submissions are not in sufficient detail to completely reconstruct the planning versus the actual expenditures for inhouse support elements. All contract files reflect both initial and supplemental funding through contract modifications.

The schedule history is reflected in the APP, DCP No. 130, contractor proposals, and contract schedules. The AN/SLQ-32 program does not submit SARs.

Significant events are also well documented. The appendices of "Lessons Learned in the Design-to-Price EW Suite Development", a Naval Electronic System Command document dated 15 October 1977, provides significant details concerning the contract definition, full scale engineering development, and test program.

The production effort is reflected in the contract file; schedule, delivery rates, ceiling price, engineering changes, and change in scope are fully delineated.

In general, the SLQ-32 program documentation provides statistical data concerning schedules, funding, and changes in performance. Project office personnel provide the rationale for most program decisions.

The level of technology required to develop the SLQ-32 was underestimated by both the Navy and industry. Of particular significance was the level of computer software dependence of the system.

5.3 (U.S. AIR FORCE) E-3A AIRBORNE WARNING AND CONTROL SYSTEM

5.3.1 Program Synopsis

The E-3A program manager is responsible for the development and acquisition of an overall airborne air surveillance capability with command, control and communication functions.

The E-3A can be deployed with strike forces to serve as a control center and extend ground capabilities in support of tactical air missions. The system can detect and track targets at high and low altitudes, over land and water. Of particular significance is its low altitude over-land capability. The E-3A, in conjunction with the Joint Surveillance System will allow a reduction in Air Defense Command (ADC) ground environment forces and tactical command and control aircraft. The E-3A program manager is also responsbile for NATO AEW&C, maritime, and U.S. enhancement programs.

The E-3A/AWACS program office is a major SPO with over 150 directly assigned personnel plus additional support from field activities.

The origin of the E-3A/AWACS program can be established as an Air Defense Command Post Study in April 1961. The E-3A is one of DoD's oldest programs. The emphasis in the early 1960's was an improvement in the low altitude/overland tracking capabilities of air defense radars. Several inhouse studies resulted in SOR-206 (Specific Operating Requirement) in 1963. Further radar feasibility studies by industry in 1964 led DDR&E to direct the USAF to initiate the AWACS concept formulation effort and an aggressive overland radar technology (ORT) program.

During 1965, the Air Force initiated competitive ORT contracts with six electronic firms, awarded competitive system configuration contracts to two system integration companies and awarded AWACS feasibility studies to three aircraft manufacturers. The AWACS program was authorized and a SPO established in 1965.

The next four years resulted in parallel concept formulation efforts, additional radar studies, command and control

studies, inhouse and OSD reviews, and changes in requirements. DCP No. I of November 1967 (Modernization of the Continental Air Defense Force) gave way to DCP No. 5 in November of 1968 authorizing an AWACS contract definition (CD). Competitive CD contracts were awarded to Boeing and McDonnell Douglas in February 1969. The Secretary of Defense approved the CD but deferred the decision on a separate tactical configuration until the results of this effort could be reviewed by OSD. The approved program was to be a fixed price incentive procurement with many of the characteristics of a total package procurement (TPP). The inventory objective was 57 aircraft.

Budget constraints caused the AWACS system to shrink from a "Baseline" to an "Austere" to a reduced capability "Core" configuration*.

Revision 2 to DCP No. 5 dated February 1970 approved the "Core" configuration program, increased the SPO to 107 personnel, established an inventory objective of 42 aircraft, and recognized a tactical application for AWACS.

The Secretary of the Air Force selected the Boeing Company as the acquisition contractor in July 1970; a contract was awarded in July. A competitive half scale brassboard radar development and test program was completed in August 1972; Westinghouse was selected as the radar contractor by Boeing in October. Airborne tracking demonstrations, flight demonstrations, and participation in Joint Exercises were a prelude for a December DSARC.

The DSARC, designated IIA, was concerned with development costs and descoped the program. Four GFE engines were

*The core configuration retained the weight, space, power, and wiring provisions for the capabilities removed.

directed instead of eight contractor furnished engines. The number of test aircraft was reduced from seven to four. Program cost estimates were revised downward, and another DSARC scheduled in nine months. FSD was authorized.

DSARC IIB in September 1973 reduced the inventory objective to 34 aircraft and stretched out the production plan. The aircraft were to be procured in FY-75, 76, and 77 in three lots.

System integration demonstrations provided sufficient data to satisfy the requests of DT&E and IOT&E. These tests, completed in October of 1974, formed the basis for authorization to proceed with production in March 1975.

DCP No. 5, Revision 3 of 5 March 1976, authorized the continuation of production and the following system enhancements: Joint Tactical Information Distribution System (JTIDS), Maritime Surface Surveillance, Expanded Command, Control and Communication (C^3)/SIGINT interface, Self-Defense Subsystems, and Electronic Counter Countermeasures.

Core configuration E-3A flight tests were completed in January 1977.

In response to guidance by OSD/HQUSAF, the E-3A/AWACS Test and Evaluation Master Plan (TEMP) has been revised to reflect the Maritime and JTIDS system improvements.

DCP No. 5 Revision 4 of March 1980 authorized the production of the US/NATO standard configuration.

The last E-3A aircraft delivery is now scheduled in 1984. An improvement program will continue after the last aircraft delivery.

The AWACS program can be characterized as follows:

- Very old program
- Well documented
- Early competitive studies
- Competitive concept formulation
- Competitive contract definition
- Single source FSD
- Competitive subsystem design
- Sole source subsystem procurement
- Single source production
- Evolving requirements
- Evolving configuration
- R&D shortfalls during development
- Schedule stretchouts
- Descoping development efforts
- Development/improvements continue after production.

5.3.2 Data Assessment

Data quality is excellent. The E-3A/AWACS is one of DoD's best documented programs.

The program development history is excellent. An AWACS development track from HQ/USAF provided extensive details of the program dating back to the early 1960s. Most of the planned data is no longer available but the program guidance and subsequent actions indicate the general plan.

Funding history as reflected in the AWACS contract file and DCPs is very good. USAF budget requests were not always available, but a clear indication of SPO requirements and the guidance requiring reduction in scope indicate the level of R&D funding problems.

The schedule history is readily available with few significant inconsistancies in different documents.

A detailed management track provided by the AWACS office in the Air Staff delineated most significant events up to early 1974. DCP, SAR and interviews provided event information up to the present. The quality of this data is excellent.

The inventory objective has changed often, usually as a result of projected costs. The current program calls for 34 aircraft including three acquired with R&D funds.

The change in performance of the AWACS over the 1961 air defense equipment was not obvious during the first ten years of the program. Overland radar technology programs in the 1960s and NATO/Maritime updates in the 1970s indicate the evolutionary nature of this program. This is also evident in the amount of guidance provided the SPO over the years. Further, extensive user participation early in the program helped define requirements and improvements.

Early level of technology estimates to meet the changing operational requirements were poor. A continuing study and evaluation program was needed. Changing technologies also had an adverse impact on the development costs.

The acquisition strategy was established early in the program. Although the schedule and contract type have changed substantially -- the strategy is the same.

5.4 JOINT PROGRAM/ALQ-165, AIRBORNE SELF-PROTECTION JAMMER (ASPJ)

5.4.1 Program Synopsis

The ASPJ program office (PMA-272) is a small organization with a core staff of eight; one-half are Navy and one-half are Air Force. The program manager is a Navy captain. The deputy program manager is an Air Force lieutenant colonel. The Naval Air Systems Command (NAVAIRSYSCOM), the parent command of PMA-272, provides direct support through a matrix organization; about 50 professionals support the ASPJ effort. Further, six government laboratories/engineering centers support the program through a tasking arrangement. The ASPJ program manager is responsible for the development and acquisition of the ALQ-165 and the ALQ-131 CPMS (Comprehensive Power Management System) for the Air Force.

The ASPJ is a major weapon system development. It is an onboard self-protective electronic warfare system designed to enhance the survivability of current and the next generation of Navy and Air Force strike aircraft. The recognition and response to threats is software controlled and may be reprogrammed in different theaters of operation or in reaction to new threats. The ASPJ system will be an integral part of other installed EW equipments, i.e., receivers, displays, chaff/decoy subsystems, etc.

In order to accommodate the physical configuration of a variety of aircraft, the ASPJ is designed in modules. These building blocks will allow both internal and external pod installations.

The ALQ-131 CPMS will interface the Air Force ALR-69, and ALR-62 with the ASPJ transmitters, the ALQ-31 and ALQ-119. For aircraft with larger radar cross sections, an augmentation package will also be designed.

The extensive use of electronic warfare equipments in Southeast Asia in the 1960s provided a technology base in government laboratories. ASPJ began in July 1969; it was called the Wide Band Dual Mode ECM project by the Naval Research Laboratory (NRL). Feasibility studies and microwave component development culminated in an advanced development model (ADM) ECM system in 1976. Many components and technology used in the ADM were from the Air Force developed ALQ-131. The Navy renamed the Dual Mode project ASPJ in 1976.

In a separate program, the Air Force was developing its Light Weight Low Cost ECM system.

The Director, Defense Research and Engineering (DDR&E) directed that the Air Force and Navy develop a common countermeasures system; the Navy was designated as lead service in developing the airborne EW suite.

Both the Navy and Air Force had competitive industrial study contracts to define the nature of a new airborne EW system. These requirements were different.

The Air Force participation in the ASPJ joint program was on again-off again. At one time, the Air Force had withdrawn completely from the ASPJ program office. An urgent need for an EW suite for the F-16 (well in advance of an ASPJ production delivery) contributed to the speculation that the Air Force would request reconsideration of the DDR&E commonality decision.

Two factors strongly influenced the acquisition strategy proposed by the project office:

- Strong DoD/OMB guidance to maintain competition into production
- An anticipated delivery rate requirement in excess of most single industrial firms.

The concept proposed and subsequently agreed to by the Navy, Air Force, and OSD involved five low level industrial studies to formulate performance specifications and design-to-cost goals (concept formulation). The next step was the voluntary establishment of teams of contractors to participate in the system development.

Two teams, Westinghouse/ITT and Sanders/Northrop, were selected for the initial design efforts. This period is similar to a contract definition and will end with a critical design review. The period of performance, however, is expected to be about 15 months rather than the more conventional 4-6 month CD effort. Proposals will be solicited from the participating teams to build engineering prototypes.

Only one team will survive. The remainder of the FSD phase will be a cooperative effort. Both members of the team will provide identical test articles.

For production, this team will be disestablished and both members will become price competitors for the production program. The initial buy is expected to be divided equally. Subsequent annual buys will be divided based on price and other factors.

Since only the FSD contractors will participate in production, a level 2 drawing package will be used for logistic functions.

Ground support equipment will be acquired through separate competitive contracts.

Initial operational software will be procured from the system designers. Operational software will subsequently be provided by a government facility.

A DSARC II review in August 1979 approved this acquisition concept. The competitive design phase began in August with the award of contracts to two teams.

In February 1980, the Chief of Staff of the Air Force announced that ASPJ would be the ECM equipment for the F-16. The Air Force now provides approximately 50% of the R&D funds and personnel for the ASPJ program.

The current ASPJ program calls for the prototype phase to extend from early 1981 through early 1983. Test and aircraft integration to span late 1982 to 1984.

Approval for Service Use (ASU) is expected in 1984, a production contract is anticipated in 1985 with first deliveries in 1985.

The ASPJ program can be characterized as follows:

- Merging of Navy/Air Force programs
- Uncertain early support by AF, OSD, Congress

- Competitive studies
- Competitive teams through D&V phase
- Single team FSD/prototyping
- Team decouples to become competitors during production
- Both competitors build same end item
- Parallel production
- Inventory objective not firm
- Joint project office
- Developmental schedule delayed due to Congressional budget cuts in 1978.

5.4.2 Data Assessment

Data quality is fair; sources are few. Although the ASPJ program has been in existence for over a decade, little data is available prior to 1976.

The actual program development history since 1976 is available but only down to major events. Planning data were difficult to recover. This was due to the evolutionary nature of the program. It is difficult to mark a clear beginning of the program for record purposes. The project office, PMA-272 was established in 1980; prior to that, it was an element within PME 107/PMA 257, a program office that reported to two Naval Commands.

Funding history since 1978 is available at the program level. Budget requests are available; authorizations at the Navy program element level are also recoverable. The actual funds provided to support organizations are also available but the funds originally planned are not. The ASPJ office does not submit SARs.

The inventory objective is also vague. U.S. requirements are general and subject to change. Total U.S. and NATO requirements may approach 5000 systems. Production costs are based on a 90% learning curve and the certainty that the U.S. requirement will be large.

The technology to support the ASPJ program is well established. The challenge is packaging the system in such a way that it can fit many different aircraft. The configuration control problems associated with dual production is acknowledged by the program office.

The statistical data associated with ASPJ are less available than any of the other programs reviewed.

5.5 SUMMARY OF DATA AVAILABILITY

It appears that both quality and quantity of statistical data are direct functions of program value and program office size. The AWACS was the oldest and best documented. It has also expended more funds to date than any other program. It has had a program office of over 100 people for the last ten years. The AAH is the next best documented program. It also has a large program office and will be the most expensive program at completion.

The SLQ-32 was the smallest program in terms of both assigned personnel and total dollars expended. The documentation is good; this is because many of the original program staff are still assigned and are able to retrieve old documents from the archives. The ASPJ has a small joint office, began without stated operational requirements, and suffered from lack of DoD/Congressional support early in its existence. It has the least documentation available.

The following summarizes the quality of data reviewed:

Program Development History

Actual history - good to excellent

Planned program - poor to fair

Funding History

Total programs (budget elements) - good to excellent

Total program as planned - fair to good

Program work packages - fair to good

Planned work packages - poor

Schedule History

Actual acquisition phases - excellent

Planned phase schedule - fair

Actual work packages* - fair to good

Planned work packages - poor

Significant Events or Milestones

Actual dates - excellent

Planned dates - fair

Inventory Requirements

At program start - good to excellent

At major milestones - good to excellent

Rationale for Inventory Changes - good

Performance Increase Required over Replaced System

At program start - poor

At major milestones - fair to good

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*beginning/ends of identifiable tasks such as DT&E, etc.

Estimate of Level of Technology Required to Support the Development

At program start - poor to fair

At major milestones - fair

It is evident from the programs examined that data exist. Data supporting actual program histories were good to excellent; data identifying differences between planned and actual occurences were inferior. In all cases, a certain amount of "digging" was required to retrieve the data, and an intense collection effort will be required to assemble sufficient data to support the development of an adequate data base.

6. CONCLUSIONS AND RECOMMENDATIONS

The objective of this research effort was to assess the feasibility of developing an analytic model for use in selecting an acquisition strategy for research, development, and production of major weapon systems. In performing this assessment, TASC has accomplished the following:

- The elements of acquisition strategy have been described as twenty-three strategy alternatives over four acquisition phases. At each decision point, the acquisition strategy is the option selected from feasible alternatives as the course of action for the current phase and a planned course of action for all subsequent phases.

- Significant factors and considerations influencing the acquisition strategy alternatives have been described. Definitions have been provided for each, they have been separated into nine groupings, and they have been categorized as to the type of influence each exerts.

- Preliminary estimates of quantitative relationships have been provided which indicate the expected result of pursuing a particular acquisition strategy by incorporating the combined impact of the relevant influencing factors and the uncertainty associated with them

- Four major weapon system acquisition programs have been examined regarding the availability of data of sufficient quantity and quality to support the development of an historical data base. It was determined that sufficient data exist, but an intense effort will be required for data collection.

As a result of these efforts, TASC has determined that the development of an analytic model for use in selecting an acquisition strategy is feasible. In the remainder of this chapter, a preliminary model description is provided, and an approach for developing both the model and the supporting data base is outlined.

6.1 A MODEL FOR ACQUISITION STRATEGY

Using the methodology described in Chapter 4, the expected result of pursuing each feasible acquisition strategy can be expressed in terms of several quantifiable attributes. Once this is accomplished, the process of evaluating the trade-offs among the inter-related and often competing objectives for a particular program is a significant task. The methodology proposed by TASC is the development of a multi-attribute utility model which can be tailored to reflect the needs and constraints of each particular program. A properly structured multi-attribute utility model would provide a means to systematically identify and structure objectives, to make vexing value tradeoffs, and to balance various risks. Once this is accomplished, the selection of an "optimal" strategy involves determining the strategy that maximizes expected utility. Various techniques exist for obtaining this strategy; a relatively simple technique is a dynamic programming algorithm described by Raiffa*. A conceptual description of the recommended model for acquisition strategy is presented in Fig. 6.1-1.

The selection of the most appropriate form of the multi-attribute utility function is an area that requires additional research. A feasible choice is the multilinear utility function:

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*Raiffa, H., Decision Analysis, Addison-Wesley, Reading, MA, 1968.

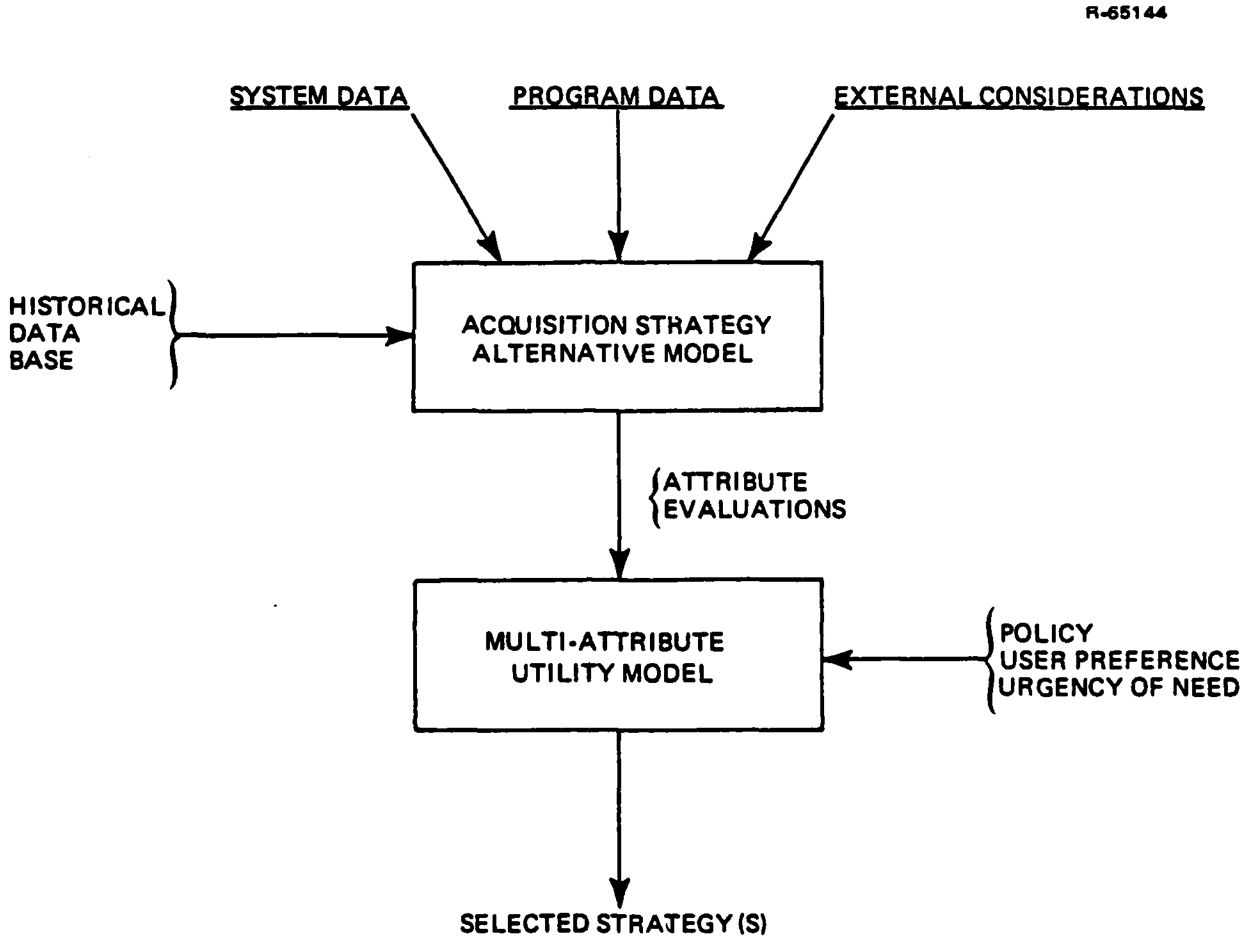


Figure 6.1-1 Conceptual Description of Model

$$u(x_1, \ldots, x_n) = \sum_{i=1}^{n} K_i u_i(x_i) + \sum_{i=1}^{n} \sum_{j>i} K_{ij} u_i(x_i) u_j(x_j)$$

$$+ \sum_{i=1}^{n} \sum_{j>i} \sum_{\ell>j} k_{ij\ell} u_i(x_i) u_j(x_j) u_\ell(x_\ell)$$

$$+ \ldots + K_{123\ldots n} u_1(x_1) u_2(x_2) \ldots u_n(x_n)$$

where

> $u_i(x_i)$ is a conditional utility function for each x_i
>
> $K_i, K_{ij}, \ldots, K_{123\ldots n}$ are scaling constants.

Adjustments for particular applications are accomplished by the appropriate selection of the scaling constants and the selection of the individual conditional utility functions.

Implementation of a model for acquisition strategy as described would, in all probability, require access to a large-scale computer. A realistic operating scenario incorporating program-specific data would involve off-line input of data followed by the pre-computation of the major attributes (those requiring larger values of computer time). An alternative scenario when less specific data is available would involve a "menu" selection of representative parameters. Either would be followed by an on-line, interactive mode where the decision-maker is asked to respond to a set of questions involving his preferences and value tradeoffs. Logical consistency checks would be incorporated. Frequently, when a problem is decomposed into parts, the initial answers to a series of questions may turn out to be internally inconsistent.

When this happens, the user will want to scrutinize his answers carefully and perhaps change some of his earlier responses so that the total pattern of modified responses is consistent and seems reasonable to him. The result of this interactive process would be the determination of the conditional utility functions for each attribute as well as the determination of the scaling constants; thus completely defining the multi-attribute utility function appropriate for the particular application. Expected utility would then be maximized and the corresponding acquisition strategy displayed along with its attributes. A sensitivity analysis module would be incorporated to allow the user to examine the sensitivity of the results to changes in critical parameters.

Properly implemented, such a model would provide a valuable tool for a program manager to sort out the conflicting values, objectives, and goals, and to arrive at a wise decision.

6.2 RECOMMENDED APPROACH FOR MODEL AND DATA BASE DEVELOPMENT

TASC recommends a three-phase research and development effort to completely implement a model and data base for acquisition strategy.

The first phase involves the development of a preliminary model and data base as described in this report. Included will be the detailed development and computerization of the modules which assess the attributes associated with each acquisition strategy, a data collection effort sufficient to obtain first-order estimates of required parameters, and further research into appropriate forms of the multi-attribute utility function.

During the second phase, the preliminary model would be applied to various major weapon system programs in order to evaluate the model and demonstrate its utility. Concurrently, data collection would continue in order to expand the acquisition strategy data base.

During the final phase, lessons learned during the previous phase would be incorporated into the model, the complete model and data base would be fully documented, and a computer program would be designed for interactive use by decision-makers in the acquisition process.

Complete details of the recommended approach, including estimated schedules and funding requirements have been provided under separate cover.

APPENDIX A
MATHEMATICAL DESCRIPTION OF THE TASC MODEL FOR EVALUATING THE EFFECT OF COMPETITION IN PRODUCTION

The TASC model for analyzing the effects of competition in production is based on unit learning curve theory and an observed phenomenon based on extensive research that learning curves are altered when competition is introduced. This phenomenon is characterized by a shift and a rotation in the learning curve when plotted in log-log form (Figure A-1).

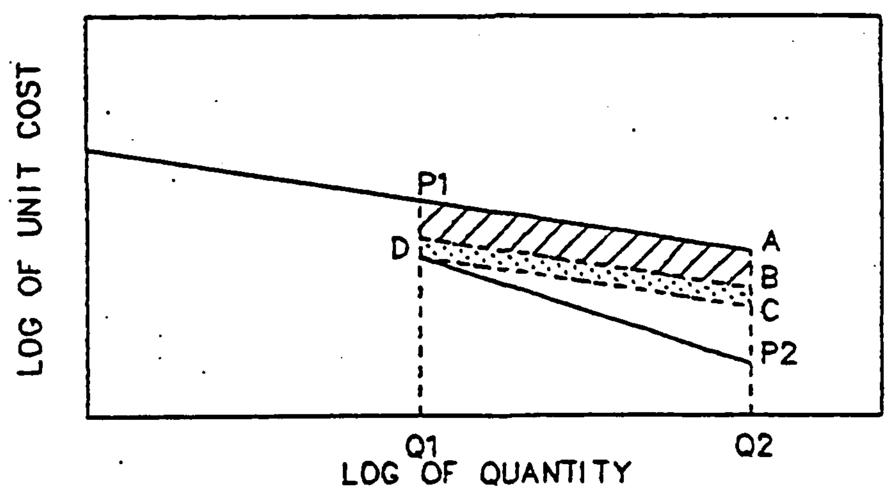


Figure A-1 Benefits of Competition

Figure A-1 assumes that production was single source Q1. At that point, competition with another firm was introd. If we assume that the original firm won a competitive t, the figure shows that the firm's price P1, fell to P2 at t the competition. Since the firm would have progressed arning curve to point A, the distance AP2 represents ngs due to competition. If the firm had won part would progress along curve segment DP2 up

to the point of its total quantity. The remaining quantity would be produced by the other firm.

The price reduction AP_2 can be divided into three parts: AB, BC, and CP_2. The curve's parallel downward shift from A to B results from the <u>reduction in profit</u>; the area just above the dotted B line represents the total savings resulting from the firm's reduced profit. The reduction from B to C represents the <u>cost reduction</u> which the firm effected, with the area between B and C representing the total savings obtained by such cost reductions. These two downward shifts are combined to represent the shift in cost due to competition. The final reduction from C to P_2 represents a reduction based upon the firm's developing, under competition, a <u>steeper learning curve</u> (i.e., a faster rate of learning). The line DP_2 reflects the steeper slope and the area in triangle DCP_2 represents the total savings as a result of increased learning. The total area in $P_1AQ_2Q_1$ represents what the total costs would have been if production remained single source. The area $DP_2Q_2Q_1$ represents the actual costs obtained under competition.

The TASC competition model estimates single source and multiple source production costs based on unit learning curve theory. This can be mathematically expressed as follows. The cost of the K^{th} production unit, C_{k1} in unit learning curve theory is:

$$C_k = A_1 K^B$$

where

$$B = \frac{\log P}{\log 2}$$

P = the learning curve rate

A_1 = the cost of the first unit

Note: If A, is unknown, but some Aj is known for unit j, A_1 can be calculated by $A_1 = Aj/j^B$.

The total cost of K units following production of N units is as follows:

$$C_N^K = A_1 \sum_{i=N+1}^{N+K} i^B$$

In order to simplify computation, the TASC model uses the following equation:

$$C_N^K = A_1 \int_{N+0.5}^{N+K+0.5} x^B dx$$

then

$$C_N^K = \frac{A_1}{B+1}\left[(N+K+0.5)^{B+1} - (N+0.5)^{B+1}\right]$$

The effects of competition on B and A are calculated as follows:

$$B^1 = \frac{\log p^1}{\log 2}$$

where

$$p^1 = p(1\text{-ROT})$$

100 x ROT = percent rotation of learning curve rate

$$A^1 = A_1(1\text{-SFT})N^{(B-B^1)}$$

where

N = number of units produced prior to competition

$100 \times SFT$ = percent reduction (a shift) in cost

Thus the cost of K units following production of N units where competition occurs after the N^{th} unit is produced is as follows:

$$C_N^K = \frac{A^1}{B^1+1}\left[(N+K+0.5)^{B^1+1} - (N+0.5)^{B^1+1}\right]$$

The incremental costs are included by adding their values to the total production costs of the dual source producers.

The computer simulation of the competition model uses the above theory to compare single source production to a competitive dual source production. Model outputs include:

- Yearly production costs
- Total costs (including incremental costs)
- Savings

The model requires the following inputs:

- Production schedules
- A unit cost and unit number
- Learning curve slope
- Learning curve shift
- Learning curve rotation
- Decision lot size

- Production start year
- Competition start year
- Incremental dual source costs
- Inflation and discount rates

The model also offers several options to perform sensitivity analysis on the input parameters. The following inputs can be examined:

- Decision lot size
- Learning curve shift
- Learning curve rotation
- Learning curve rates
- Unit costs

In addition, the model offers a buyout option. This option calculates the associated costs and savings resulting from an additional competition with the winner producing all units.

APPENDIX B

DATA SUPPORTING THE TASC MODEL

The size of the savings which are extracted from competition are directly affected by the magnitude of the shift and rotation. The most direct method for measuring these parameters is to estimate learning curves for firms which participated in a program both as a sole source or directed buy producer and as a competitive producer. TASC has performed such an analysis for various selected programs. The following is a description of the data, methods of analysis, and results.

Two crucial observations from the data analysis are:

- A 'best-fit' learning curve does not always produce the most accurate sole source curve for projecting sole source costs beyond the point of competition.
- The time period where the government states that competition occurred and the period where the contractors act competitively (i.e., where a shift and a rotation are observed for their cost improvement curve) do not always coincide.

Table B-1 presents two sets of shifts and rotations for each case. The least squares best-fit method* calculates

*When assessing the learning curve most representative of observed data, several methods have traditionally been used. The most frequently encountered method involves the estimation of lot midpoints and applying the least squares curve-fitting method to the log-log curve. This approach simplifies the calculations involved, but it does not necessarily yield correct results since true lot midpoints will vary depending on the slope and the quantity produced. The methodology used by TASC is more complicated, but also mathematically correct. The least squares method is applied to the cumulative unit learning curve, and the resulting equations are solved by applying Newton's method. The methodology is computerized so that the calculations can be performed rapidly and accurately.

Table B-1

Calculated Shifts and Rotations Using Alternate Methods

Program	Contractor	BEST-FIT Shift (In Percent)	BEST-FIT Rotation (Percentage Points)	SEGMENTED Shift (In Percent)	SEGMENTED Rotation (Percentage Points)
Sparrow	(Raytheon)	2	5	7	9
	(GD)	0	0	11	15
Bullpup	(Martin)	14	11	19	7
Sidewinder-9B	(GE)	26	23	9	14
750 Bomb, M117		11	20	17	7
Average		11	12	13	10

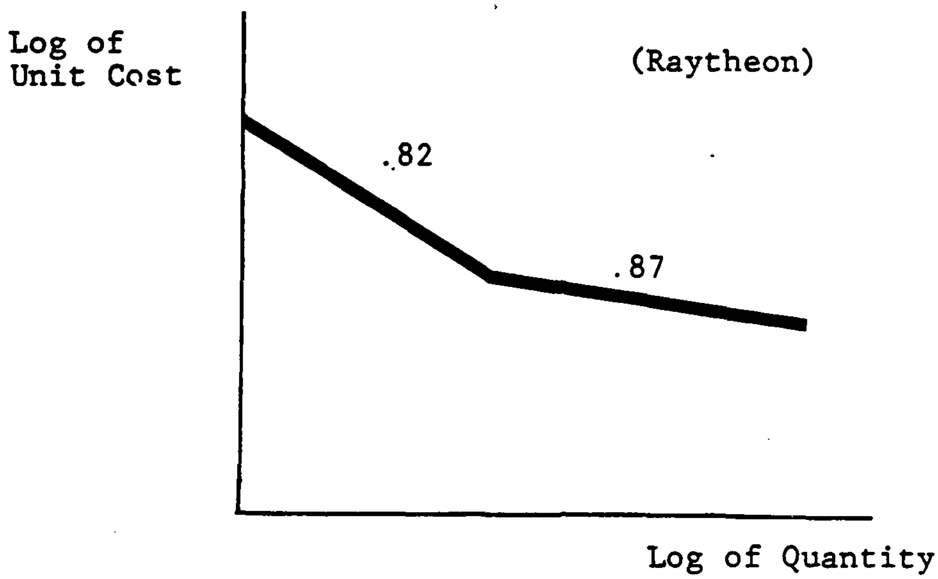
a cost improvement rate by fitting a curve to all data points. The best-fit curve is then used as the projected sole source rate when calculating savings due to competition. The alternate (segmented) method calculates cost improvement rates for segments or parts of the curve and places a higher weight on the more recent segments when calculating a sole source curve for projection. The Sparrow AIM-7F data provides a good example.

An examination of the log-log segmented graphs (Figure B-I) for both 7F producers helps to illustrate the best-fit drawback. Both graphs, prior to competition, display convex log-log cost improvement curves. Simply stated, the learning rate deteriorates as quantity produced increases. Examination of cost-improvement curve literature and discussions with government contracting officials indicate that production during small early lots of weapon system procurement is often not fully automated. As lot size increases, production processes become more established and more fully automated. The cost improvement curve rate which is observed for the more recent and larger production lots is a more accurate predictor for projecting sole source costs than a best-fit curve which is heavily skewed by the small early buys. In the case of General Dynamics, the difference is especially pronounced, with a 16 percentage point difference between the .71 best-fit and the .87 segmented sole source (directed buy) curves. It is interesting to note that the sole source rate, using the segmented technique, is approximately 87% for both contractors.

This segmented approach is applicable in situations other than the convex sole source curve. Concave log-log sole source curves or convex log-log competitive curves are other situations where the segmented approach may prove analytically useful.

Segmented Sole Source Cost Improvement Curves (Log-Log)

Sparrow AIM-7F



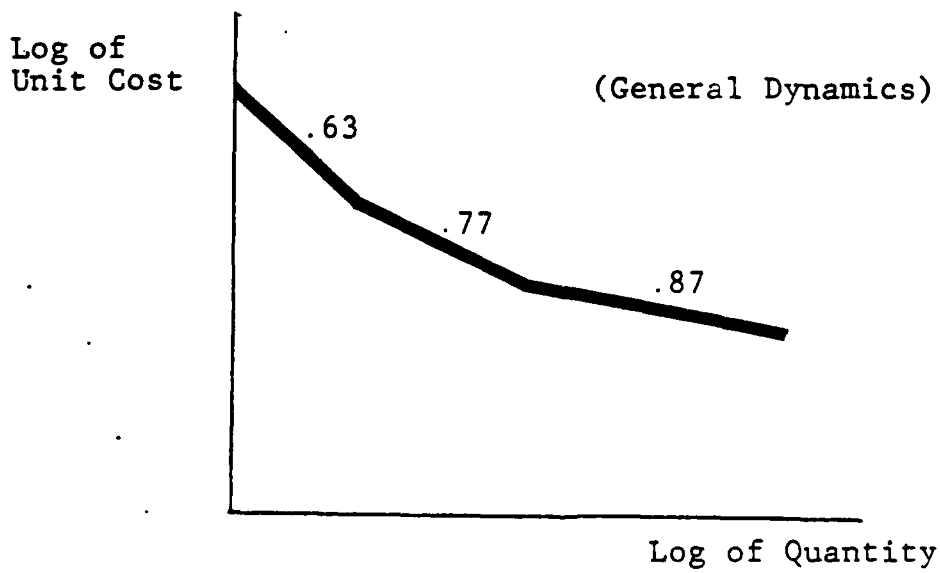


Figure B-1

The average parameters for the two methods on Figure B-I show similar results:

- The 12% shift parameter that TASC used for its predictive model is reasonable.
- The 5% rotation parameter that TASC uses for the predictive model appears very conservative.

The Sparrow data also illustrates an important aspect of the timing of competitive effects. According to the government, competition was initiated for the FY77 award. Although the observed shift and rotation for the sole source firm (Raytheon) occurred at this time, the competitively induced shift and rotation for General Dynamics, the second source, did not occur until the FY78 award. Without further information, only speculation as to the factors which delayed the competitive effects (e.g., necessity for additional learning quantities, maximization of second source position, competitive strategy) is possible. But when estimating parameters for the model, it is important to distinguish the difference between the assumed point of competition and the point where competitive behavior is observed.

A brief description of each program examined and a listing of the price and quantity are included on the following pages. All of the cost data are for recurring expenses and are presented in constant dollars.

Sparrow AIM-7F

The cost and quantity data for the Sparrow AIM-7F air-to-air missile, guidance and control section, was extracted from an outline of a NAVAIR briefing, which was delivered to the Defense Science Board, 1 August 1979. The guidance and control section, which composes 80-90% of the missile cost, was developed and initially (sole source) produced by Raytheon. Sole source production began in 1973. General Dynamics was introduced as a second source producer and eventual competitor. According to government information, competition was initiated for FY77.

	Raytheon		General Dynamics	
FY	Quantity	Unit Cost	Quantity	Unit Cost
73	150	$ 151,367		
74	75	104,712	15	$ 610,820
75	600	79,167	70	149,365
76	800	65,721	210	89,600
77	1110	51,676	210	76,816
78	1398	43,723	750	51,218
79	900	39,412	1310	35,295

Table B-2
SPARROW COST DATA

750 Pound Bomb, M117

Letourneau was one of three producers for the 750 pound bomb, M117 series. Production was initially split equally between the three producers, with the real competitive process apparently beginning somewhere between 1967 and 1969. Letourneau's shift and rotation was observed for the FY69 production buys. Data are grouped by fiscal year.

Letourneau (Longview Plant)

FY	Quantity	Unit Cost
65	59000	$ 402.
66	145007	302.
67	179552	268.
68	324000	244.
69	394140	200.
70	276400	160.
71	396236	145.
72	254000	138.

Table B-3

750 POUND BOMB DATA

Data are from 'Forecasting Savings from Repetitive Competition with Multiple Awards', Army Procurement Research Office, 1979

Bullpup AGM-12B

The Bullpup AGM-12B missile was initially sole source produced by the Martin Company in 1958. (Actually, the initial 1958 production lot was for the AGM-12A, but A and B configurations only slightly differed and are comparable for cost analysis.) Martin produced sole source until 1961, when competition was initiated. Again, data are presented for the guidance and control section and grouped by fiscal year.

Martin

FY	Quantity	Unit Cost
58	700	$ 12,040.
59	3015	6,687.
60	3805	4,987.
61	4453	3,571.
62	15904	2,486.
63	9155	2,047.

Table B-4

BULLPUP AGM-12B COST DATA

Data are from 'Analysis of Competitive Procurements', by Arthur J. Kluge and Richard R. Liebermann, Tecolote Research, Inc., 1978

Sidewinder AIM-9B

General Electric began its production of the Sidewinder AIM-9B air-to-air missile in 1956. It is not clear when competition was initiated, but General Electric's shift and rotation was observed for the FY59 production lot. Cost figures are for the guidance and control section.

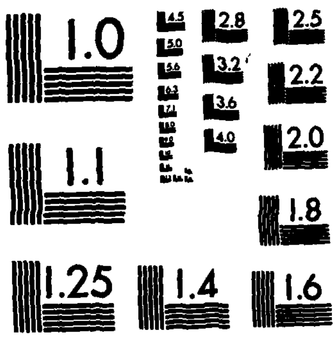
General Electric

FY	Quantity	Unit Cost
56	200	$ 5,555.
57	7500	3,966.
58	3585	2,884.
59	5902	2,341.
60	4407	1,831.
61	5256	1,474.
62-63	13188	1,633.
64	1155	1,220.

Table B-5

SIDEWINDER AIR-9B COST DATA

Data are from 'Analysis of Competitive Procurements', by Arthur J. Kluge and Richard R. Liebermann, Tecolote Research, Inc., 1978



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

APPENDIX C

PROPOSED GENERALIZATION OF THE TASC MODEL FOR ANALYZING THE EFFECTS OF COMPETITION IN PRODUCTION TO ESTIMATE COSTS OF ALL PRODUCTION ALTERNATIVES

The TASC model for analyzing the effects of competition in production is based on unit learning curve theory and an observed phenomenon that learning curves are altered when competition is introduced. The concept that the learning curves associated with varying situations can be characterized by changes in the parameters defining the curves forms the basis for this proposed generalization; very simply, each of the strategy alternatives for production can be characterized by a set of learning curve parameters (and associated alterations to those parameters) which is unique for each strategy alternative. Incorporating the uncertainty in the parameters by the use of a probability distribution for each completes the proposed generalization.

For those strategy alternatives involving only one contractor (e.g., sole source with no options, sole source with options, and sole source multi-year contract), the following methodology is appropriate.

Given:

$f_{T,Q}(t,q) \equiv$ joint probability density of the time and quantity to be produced (i.e., a probabilistic description of a production schedule)

$f_A(a) \equiv$ probability density function of the first unit cost. In all likelihood this

is also a function of the strategy alternative during FSD (e.g., if competition were present during FSD, first unit cost may be lower than if FSD were also single source)

$f_P(p) \equiv$ probability density function of the learning curve slope (also very likely a function of the strategy alternative during FSD).

Then

$f_Q(q) \equiv$ probability density function of the total production quantity

$$f_Q(q) \equiv \int_0^{\infty} f_{T,Q}(t,q)\, dt$$

$f_T(t) \equiv$ probability density function of total production time

$$f_T(t) \equiv \int_0^{\infty} f_{T,Q}(t,q) dq$$

$F_{Q|T}(q) \equiv$ the conditional probability density of production quantity given the production time = T

$$F_{Q|T}(q) = \frac{f_{T,Q}(t,q)}{f_T(t)}$$

and $F_{C|T}(c) \equiv$ conditional probability distribution of production cost given production time = T

$$F_{C|T}(c) = \int\cdots\int_D \quad f_{Q|T}(q)\ f_A(a)\ f_P(p)\ dqdadp$$

when

$$D = \{(q,a,p) : \frac{a}{b+1} [(q+0.5)^{b+1} - 0.5^{b+1}] \leq c,$$

$$b = \frac{\log p}{\log 2}$$

Accordingly,

$f_{C|T}(c)$ = conditional probability density of the production cost given production time = T

$$f_{C|T}(c) = \frac{d}{dc} F_{C|T}(c)$$

and finally $f_{C,T}(c,t)$ = joint probability density of the production cost and time

$$f_{C,T}(c,t) = f_{C|T}(c)\; f_T(t)$$

For strategy alternatives involving two contractors (i.e., dual sourcing, licensing, and leader/follower), the formulation will be similar to that presented but somewhat more complex. A complete formulation is not included.

APPENDIX D
LIST OF PERSONS INTERVIEWED

Capt. H.W. Alexander, Program Manager A-6, Naval Air Systems Command

Mr. F.O. Angel, Project Management Office, U.S. Army Material Development and Readiness Command

CDR. R.F. Beal, Electronic Warfare Systems, Anti-Air Warfare Branch (OP-352), Office of the Chief of Naval Operations.

Mr. Wayne Becker, Office of the Comptroller, Department of Defense

CDR. W.R. Blakeley, Commanding Officer, U.S.S. McCandless, Test Ship for the SLQ-32

Mr. A. Boykin, Consultant to the U.S. Air Force Systems Command, Wright-Patterson AFB, Ohio

Mr. C. Carawan, Procurement Plans and Policy Division, Naval Electronic Systems Command

Capt. W. Carlson, Program Manager, ASPJ. PMA 272, Naval Air Systems Command

Mr. R. Cheslow, Systems Planning Corporation, Arlington, VA, Formerly with Logistics Management Institute.

Mr. L.A. Cosby, Superintendent, Tactical Electronic Warfare Division, Naval Research Laboratory

Mr. C. Diesenroth, Program Manager, SLQ-32, Raytheon Co., ESD Santa Barbara, CA

Mr. K. Fixman, General Accounting Office, Washington, D.C.

RADM E.B. Fowler, Commander, Naval Electronic Systems Command

Mr. M. Fowler, Former PCO AWACS/E-3A, ESD, Hanscom Field, MA

Mr. F.R. Freiman, RCA Corporation, Cherry Hill, NJ

RADM A.A. Gallotta, Director, Electronic Warfare and Cryptology Division, Command and Control (OP 944), Office of the Chief of Naval Operations

Mr. J. Hall, Contracting Officer, AAH Program Office, AVRADCOM, St. Louis, MO

Mr. R.M. Hill, Electronic Warfare Branch, Contracts Directorate, Naval Electronic Systems Command

Dr. E.L. Hullander, George Washington University, Washington, D.C.

LTC. B.G. Jones, Washington Field Office, Advanced Attack Helicopter Program

Dr. C.W. Kelly, Decisions and Designs, Inc., McLean, VA

Mr. F. Kelly, Harbridge House, Washington, D.C.

Capt. J.L. Krumweide, Director of the Combat Systems Sensor Branch (OP-351), Office of the Chief of Naval Operations

Mr. E. Langenbeck, R&D Plans Division, Office of Research, Development, Test and Evaluation, Chief of Naval Operations

Capt. H.M. Leavitt, Jr., Program Manager, REWSON Systems, Naval Electronic Systems Command

Mr. Wm. Lewis, Staff Assist. for Electronic Warfare, Office of the Deputy Assistant Secretary of the Navy for C^3I

LTC. R. Lohr, Project Management Officer, U.S. Army Material Development and Readiness Command

M.E. Lovett, Department of Energy, Washington, D.C., Formerly with U.S. Army Procurement Research Office

LTC. R. Machen, Defense Systems Management College, Fort Belvoir, VA

Capt. D.R. Mathews, PMA-256, Naval Air Systems Command

Mr. J. McKeown, Acquisitions Research, Defense Systems Management College, Fort Belvoir, VA

Mr. R.A. Moye, Acquisitions and Programs Branch, Office of the Chief of Naval Material

Mr. Irwin Neveleff, Central Cost Analysis Group, Naval Electronics Systems Command

Mr. J.P. O'Brien, Systems Engineering Branch AN/SLQ-32 Project, Naval Electronic Systems Command

LTC. J.R. Patrick, AWACS PM Aeronautical Systems, Research Development and Acquisitions, HQ USAF

Col. M.L. Piper, Director of Aeronautical and Operational Support Systems, Guidance Systems Command

Mr. J.R. Polito, Department of Energy, Formerly in Acquisition Policy, Office of the Chief of Naval Material

Mr. F.M. Robinson, Director, Acquisition Planning/Policy Office, Naval Sea Systems Command

LTC Jas. J. Satterwhite, Aviation Systems Division (AAH), Deputy Chief of Staff for Research, Development, and Acquisitions, General Staff, U.S. Army

Dr. S.N. Sherman, George Washington University, Washington, D.C.

CAPT. V.D. Shirley, Command and Control, EW & Sensors Section, Tactical Air Surface and EW Development Division, Office of Research and Development, Chief of Naval Operations

CDR G.L. Smith, Program Manager, AN/SLQ-32, Naval Electronics Systems Command

Mr. J.J. Sullivan, Deputy Program Manager, AN/SLQ-32, Naval Electronic Systems Command

Mr. R. Veale, SLQ-31, Program Manager, Hughes Aircraft Company, Fullerton, CA

Mr. E. Wright, Contracting Officer for the AN/SLQ-32, Naval Electronics Systems Command

Mr. Glen Zauber, Cost Analysis Improvement Group, Program Analysis and Evaluation, Office of the Secretary of Defense

APPENDIX E
BIBLIOGRAPHY

Air Force Planning Guide, Mission Area Analysis. Washington: Depatrment of the Air Force, 15 November 1978.

Air Force Systems Command Report. Subject: "Project ACE Findings and Progress Report," [Washington]: n.n. June 1974.

Beaufre, D'Armee Andve, "An Introduction to Strategy," Fredrick A. Proeger, New York, 1965.

Blue Ribbon Defense Panel. "Report to the President and the Secretary of Defense on the Department of Defense. Appendix E. Staff Report on Major Weapon System Acquisition Process." Department of Defense, Washington, D.C., July 1970. (AD 776 058).

Brown,R.V. "Do Managers Find Decision Theory Useful?" Harvard Business Review 48-3 (May-June, 1970): 78-89.

Buede, Dennis M., and Ragland, Janice E., Cost-Benefit Analysis Applied to the Program Objectives Memorandum (POM). Decision and Designs, Incorporated, November 1978.

Burt, David N., "A History of DoD Procurement 1789-1960." Course material prepared for the Procurement and Acquisition Management Course, School of Systems and Logistics, AFIT, Wright-Patterson AFB, Ohio. (Mimeographed).

Calaway, P.R., Assistant for Program Planning, Office of the Undersecretary of Defense for Research and Engineering. "OMB Circular A-109: How It Affects R&D and IR&D." Program Managers Newsletter. Vol. VII, No. 4 (May-June 1978), pp. 9-11.

Carter, Gregory A., "Directed Licensing: An Evaluation of a Proposed Technique for Reducing the Procurement Cost of Aircraft." Rand Report Number R-1604-PR. The Rand Corporation, Santa Monica, California, December 1974. (AD A007 064).

Clark, Charles L., "Leader/Follower Program -- ACES II Ejection Seat," Proceedings Seventh Annual Acquisition Research Symposium. 353-355. Hershey, Pennsylvania. Air Force Business Research Center, Wright Patterson Air Force Base, Ohio, June 2, 1978.

Cheney, William Fitch, "Strategic Implications of the Experience Curve Effect for Avionics Acquisitions by the Department of Defense," Air Force Business Research Management Center, Wright-Patterson AFB, Ohio 45433, August 1977.

Commission on Government Procurement, "Report of the Commission on Government Procurement, Vol. 2, Part C, Acquisition of Major Systems," Government Printing Office, Washington, D.C. 1972.

Department of Energy Order 5700.1. "Major Systems Acquisitions" [Washington]: n.n. September 1978.

De Lauer, Richard D., Chairman. Report of the Acquisition Cycle Task Force, Defense Science Board 1977 Summer Study. Washington: Department of Defense, 15 March 1978.

Duncan, Charles W. Jr., Deputy Secretary of Defense. "Defense's Streamlined Acquisition Program," Commanders Digest, Vol. 21, No. 7 (May 18, 1978), pp. 2-11.

Edwards, Ward, How to Use Multi-Attribute Utility Measurement for Social Decision-Making. Technical Research Institute, University of Southern California, August 1977.

Eils, Lee C., III, and John, Richard S., A Criterion Validation of Multi-attribute Utility Analysis and a Group Communication Strategy. SSRI Research Report 78-4. Los Angeles: Social Science Research Institute, University of Southern California, December 1978.

Evans, Captain Stuart J., "National Security Management Procurement." Washington, D.C., Industrial College of the Armed Forces, 1968.

Fischoff, Baruch. The Art of Cost-Benefit Analysis. Technical Report PTR-1042-77-2. Eugene, Oregon: Decision Research, a Branch of Perceptronics, February 1977.

Flint, Grant S., and Franklin W. Jesser. Inspection and Acceptance of Contractor-Prepared Engineering Data. A student thesis, School of Systems and Logistics, AFIT, Wright-Patterson AFB, Ohio, 1972.

Fox, J. Ronald. Arming America. Boston: Harvard University Press, 1974.

Griffiths, Kenneth D., and Robert F. Williams. "Transmission of Procurement Technical Requirements in the Competitive Reprocurement of Military Design Equipment." PRO Project 70-5. Army Procurement Research Office, Institute of Logistics Management Center, Fort Lee, Virginia, June 1971. (AD 727 650).

Hall, G.R., and R.E. Johnson, "Aircraft Co-Production and Procurement Strategy," R-450-PR, The Rand Corporation, Santa Monica, May 1967.

Hall, G.R., and R.E. Johnson, "Competition in the Procurement of Military Hard Goods." A Research Paper. The Rand Corporation, Santa Monica, California, March 1968. (AD 667 558).

Harman, Alvin J., "Choice Among Strategies for Systems Acquisitions," Rand Corporation, Santa Monica, California, 1972.

Hays, Michael L., O'Connor, Michael F., and Peterson, Cameron R., An Application of Multi-Attribute Utility Theory: Design-to-Cost Evaluation of the U.S. Navy's Electronic Warfare System. Technical Report DT/TR 75-3. McLean, Virginia: Decisions and Designs, Incorporated, October 1975. AD A029987.

Hoppe, Captain Darrell R. "Dual Awards and Competition -- You Can Have Both," Proceedings Seventh Annual Acquisition Research Symposium. 344-346. Hershey, Pennsylvania. Air Force Business Research Center, Wright-Patterosn Air Force Base, Ohio, June 2, 1978.

Introduction to Military Program Management. A text for Defense Systems Management School. Logistics Management Institute, Washington, D.C., March 1971.

Johnson, Robert E. "Technology Licensing in Defense Procurement: A Proposal." Rand Report P-3982. Rand Corporation, Santa Monica, California, November 1968. (AD 681 117).

Kalal, Gerald W., and Patrick J. Gannon. "Ammunition Cost Research Study," HQ, U.S. Army Armament Command, Cost Analysis Division, Rock Island, Illinois 61201, June 1976.

Keeney, Ralph L., and Raiffa, Howard, Decisions with Multiple Objectives: Preferences and Value Trade-Offs, John Wiley and Sons, NY, 1976.

LeMartin, F.H., Jr. "Determining the Economic Value of Reprocurement Data," Defense Management Journal, Spring, 1971, 48-58.

Lawson, Dianne and Damon L. Osterhus. "A Conceptual Model of the Department of Defense Major System Acquisition Process." Unpublished MS Thesis. School of Systems and Logistics, Air Force Institute of Technology (AU), Wright-Patterson AFB, Ohio, June 1978. (AD A059 183).

Lenk, Barry R., "Government Procurement Policy: A Survey of Strategies and Techniques." Project NR 347 020, Office of Naval Research, School of Engineering and Applied Science, Institute for Management Science and Engineering. The George Washington University, Washington, D.C., May 12, 1977. (AD A041 820).

Logistics Management Institute, "Sole Source Spare Parts Pricing," TASK 4C-1 [Washington]: n.n. 1964.

Lorette, Richard J., "Major Acquisition Problems, Policy and Research," National Contract Management Journal, Winter 1976-1977, pp. 1-15.

Lovett, E.T., M.G. Norton and D.L. Herington, "Impact of Competing Previously Sole Source/Non-Competitive Contracts," Army Procurement Research Office, Fort Lee, Virginia 23801 APRO 709-1, August 1978 (CONFIDENTIAL).

Lovett, E.T., and M.G. Norton, "Determining and Forecasting Savings from Competing Previously Sole Source/Non-Competitive Contracts," Army Procurement Research Office, Fort Lee, Virginia 23801, APRO-709-3, October 1978.

McKie, James W., "Proprietary Rights and Competition in Procurement," Memorandum RM-5038-PR, The Rand Corporation, Santa Monica, California, June 1966. (AD 639 732).

Molander, Earl A., "Sole-Source Contracting: The Industry View," Aerospace Historian, 24:11-14 (March 1977).

National Aeronautics and Space Administration Management Instruction 7100.14A. Major Systems Acquisitions. Washington: National Aeronautics and Space Administration, April 19, 1978.

Neate, John D. and Malcolm A. Burgess, "Assessment of Historical Cost Data Regarding the Effects of Competition of DoD/Military Procurement Cost," ARINC Research Corporation Annapolis, Maryland 21401, Publication 6411-15[illegible]. November 1976.

O'Connor, Michael F., Rhees, Thomas R., and Allen, James J., A Multi-Attribute Utility Approach for Evaluating Alternative Naval Aviation Plans. Technical Report DT/TR 76-16. McLean, Virginia: Decisions and Designs, Incorporated, September 1976. AD A035 860.

Office of Federal Procurement Policy Pamphlet No. 1. Major System Acquisitions: A Discussion of the Application of OMB Circular No. A-109. Washington: Office of Management and Budget, August 1976.

Office of Management and Budget Circular No. A-109. Major System Acquisitions. Washington: Office of Management and Budget, 5 April 1976.

Office of the Secretary of the Navy Report, Subject: "Report of the Navy and Marine Corps Acquisition Review Committee, (NMARC)." [Washington]: n.n. April 1975.

Olson, Major A.E., Captain J.A. Cunningham, and Captain D.J. Wilkins, "A Cost-Benefit Analysis of Competitive Versus Sole-Source Procurement of Aircraft Replenishment Spare Parts," School of Systems and Logistics, AFIT, Wright-Patterson AFB, Ohio January 1974.

Peck, M.J., and F.M. Scherer, The Weapons Acquisition Process: An Economic Analysis, Graduate School of Business Administration, Harvard University, 1962.

Perry, William J., Under Secretary of Defense for Research and Engineering, Testimony before the Subcommittee on the Department of Defense, Committee on Appropriations, House of Representatives, February 22, 1978, Department of Defense Appropriations for 1979, Part 3, Government Printing Office, pp. 381-553.

Perry, Robert et al. "System Acquisition Strategies." Report R-733-PR/ARPA. A Report prepared for United States Air Force Project RAND and Advanced Research Projects Agency. The Rand Corporation, Santa Monica, California, June 1971. (AD 730 921).

Raiffa, Howard, "Decision Analysis - Introductory Lectures on Choice under Uncertainty," Reading, Massachusetts, Addison-Wesley, 1968.

Roesch, Maurice A., III, "A Methodology for Defense Systems Acquisitions," Ph.D. dissertation, School of Engineering and Applied Science, University of Virginia, May 1979.

Scherer, F.M., The Weapons Acquisition Process: Economic Incentives, Graduate School of Business Administration, Harvard University, 1964.

Sidney, W.A., "The Defense System Acquisition and Review Council: A Study of Areas of Consideration Affecting the Functions and Process of Defense Major Systems Acquisition," A Research Paper. Systems Management Center, University of Southern California, Los Angeles, California, September 15, 1976. (AD A037 021).

Soderquist, Larry L., "Leader/Follower: An Analysis of a Proposed Technique for Increasing Competition in Air Force Weapon Systems Procurements," Air Force Institute of Technology, Wright-Patterson AFB, Ohio 45433, September 1979.

Solynsky, Kenneth S., "A Procurement Strategy for Achieving Effective Competition While Preserving an Industrial Mobilization Base," U.S. Army Electonics R&D Command, Night Vision and Electro-Optics Laboratory, Fort Belvoir, VA 22060, (UNCLASSIFIED).

Smith, Charles H., "An Analysis of Acquisition Alternatives for the U.S. Army's General Support Rocket System," APRO 928, August 1979.

Stewart, Charles F., "Milestone 0 and the Mission Element Need Statement," Air Command and Staff College, Air University, Maxwell AFB, Alabama 36112, 1979.

U.S. Congress. House of Representatives, Committee on Armed Services. Subcommittee on Research and Development, "Statements on Behalf of the Aerospace Industries Association of America, Inc., Concerning OMB Circular A-109," Hearing, 95th Cong., 2nd Sess., April 14, 1978. Washington: Government Printing Office, 1978.

U.S. Department of the Air Force. "Acquisition Program Management," AFR 800-2, [Washington]: n.n. 1978.

U.S. Department of the Air Force. "Engineering for Defense Systems," AFR 800-3, [Washington]: n.n. 1976.

U.S. Department of the Air Force. "Statement of Operational Need," AFR 57-1, [Washington]: n.n. 1978.

U.S. Department of the Army. "Basic Policies for Systems Acquisitions," AR 1000-1 [Washington]: n.n. 1978b.

I.S. Department of the Army. Office of the Deputy Chief of Staff for Research, Development, and Acquisition, "ASARC/DSARC Procedures," ODCSRDA Regulation 15-14, [Washington]: n.n. 1978a.

I.S. Department of the Army Report, Subject: "Report of the Army Material Acquisition Review Committee (AMARC)," [Washington]: n.n., April 1974.

I.S. Department of Defense Directive 5000.1. Acquisition of Major Defense Systems. Washington: Department of Defense, 19 March 1980.

I.S. Department of Defense Instruction 5000.2. Major System Acquisition Procedures. Washington: Department of Defense, 19 March 1980.

I.S. Department of Defense. "Defense Acquisition Executive," DoD Directive 5000.30, [Washington]: n.n. 1976.

I.S. Department of Defense. "Cost Improvement Group," DoD Directive 5000.4, [Washington]: n.n., June 1976.

I.S. Department of Defense. "Design-to-Cost" DoD Directive 5000.28, [Washington]: n.n., October 1976.

I.S. Department of Defense. "Mission Element Need Statement," Memorandum from the Under Secretary of Defense for Research and Engineering (William J. Perry), [Washington]: n.n., January 18, 1978.

I.S. Department of the Navy, Naval Ocean Systems Center. "Project Managers Guide," 1st ed. NOSC TD 108 [San Diego, California]: n.n., June 1, 1974.

I.S. Department of the Navy, Headquarters Marine Coprs. "System Acquisition Management Manual" MCO P5000.10 (draft) [Washington]: n.n. 1979.

I.S. Department of the Navy, Secretary of the Navy. "Systems Acquisition Process in the Department of the Navy," SECNAV INST 5000.2 [Washington]: n.n. 1978.

I.S. Department of the Navy. Naval Operations - Space, "Weapons Systems Selection and Planning," OPNAV SPACE INST 5000.42 [Washington]: n.n. 1974.

'uspeh, Larry, "The General Advantages of Competitive Procurement Over Sole Source Negotiation in the Defense Department," Joint Economics Committee, Congress of the United States, 12 November 1973.

Zusman, Morris, et al., "A Quantitative Examination of Cost-Quantity Relationships, Competition During Reprocurement, and Military Versus Commercial Prices for Three Types of Vehicles," Institute for Defense Analysis, Arlington, Virginia 22202, Volumes I and II, March 1974.